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Molding Sands of Pennsylvania

By

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and

American Foundrymen's Association

Department of Forests and Waters
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MOLDING SANDS OF PENNSYLVANIA

By R. W. Stone

with

TESTS OF PENNSYLVANIA MOLDING SANDS

by the

American Foundrymen's Association.

AMERICAN FOUNDRYMEN'S ASSOCIATION AND NATIONAL RESEARCH COUNCIL.

The charter of the American Foundrymen's Association defines a foundry operator as anyone "concerned in the casting of any kind of metal in sand, or loam moulds, for any purpose," and asserts that the purpose of the association is "to promote the technical interests of the foundry industry."

This association, organized May 12, 1896 and incorporated July 3, 1916, had 1,754 members in 1925. The problems presented and discussed at its meetings are only less numerous than the membership. Among these problems are those which have to do with the use and disposal of molding sand. The American Foundrymen's Association realized the need for definite information as to the constitution of molding sands as a basis for answering some of the questions propounded by its numerous membership and determined to study the problem thoroughly. The interest and cooperation of the National Research Council was enlisted through its Engineering Division, and funds for starting the work were contributed privately. The National Research Council invited to membership in a joint committee of the two organizations, foundrymen, metallurgists, geologists, and others who have a practical or theoretical knowledge of some phase of the subject.

The Joint Committee on Molding Sand Research organized by the American Foundrymen's Association and the National Research Council numbers about 40 men. The Joint Committee is subdivided into committees on tests, geological surveys, and reclamation. The writer was an original member.

The Sub-Committee on Tests has for its duty the devising of means for testing molding sands which shall become standard methods.

The Sub-Committee on Geological Surveys has undertaken to interest the State Geological Surveys in making a field examination of their developed and prospective molding sand resources and in furnishing samples of the same for testing by standard methods devised by the Sub-Committee on Tests.

The Sub-Committee on Reclamation, knowing that foundries in the United States spend from $5,000,000 to $7,500,000 a year for new molding sand, is interested in finding some means whereby more of the used sand may be used again.

The State Geologist of Pennsylvania, George H. Ashley, accepted the proposal of the Joint Committee to cooperate in the undertaking by furnishing samples of Pennsylvania molding sand, which would be tested in designated laboratories. The writer collected samples in the summers of 1923-25 and shipped them to the laboratory at Cornell University, Ithaca, New York, where standard tests were made under the supervision of Professor H. Ries, and with the financial assistance of the American Foundrymen's Association.

PRODUCERS

A list of producers of molding sand obtained from the United States Geological Survey served as a basis for beginning the work. This list, with changes, and arranged by kind of product, includes about 70 names.

Producers of bonded molding sand

Art Bronze and Iron Works, Danville
Ed. Bollinger, Ruffsdale
Brennan Sand Co., Tullytown
S. H. Croan, Dover
Danville Stove & Mfg. Co., Danville
Eastern Clay Products, Inc., Ridgway (Hutchins)
A. C. Edwards, Broad Ford
Thos. Elmes, R. D. 5, Catawissa
E. D. Fickes, Dover
C. J. Fisher, Catawissa
Fleurie Acme Motor Truck Co., New Cumberland
A. N. Foltz, Waynesboro
Gardner Sand Co., Ridgway
Gratztown Sand Co., 1507 Kennan Bldg., Pittsburgh
W. W. Gulick Sand Co., Danville
Oscar Heath, Emporium
Hoey & Gallaher, Kittanning
C. O. Hunsicker, 17 N. 7th St., Allentown (Emaus)
James Jiles Co., Stayton & Highwood St., N. S. Pittsburgh
Louis Kemp, Commonwealth Bldg., Allentown (Lehighton)

Samuel C. Loreman, R. D. 5, Catawissa
J. K. McIntire, Perryopol's
Marietta Sand Co., Marietta
J. W. Paxson Co., Philadelphia (Tullytown)
Peerless Sand Co., Conneaut, Ohio (Girard, Springfield)
Chas. Pettinos, 25 Church St., New York City (Catawissa, Chas. Poke)
Geo. F. Pettinos, Real Estate & Trust Bldg., Philadelphia (Catawissa, Tullytown)
Geo. A. Ready, 151 W. 3rd St., Oil City
L. P. Rex, Slatedale (o. b.)
H. C. Saylor, 1730 Wallace St., Philadelphia (Hamburg)
Schuylkill Valley Sand Co., Berne
Superior Sand Co., 511 Guardian Bldg., Cleveland, Ohio (Atlantic)
C. L. Tittle, Blairsville
Union Sand Co., Conneaut, Ohio (West Springfield)
Walker Sand Co., West Springfield
West Penn Sand Co., S. H. Frederick, Secty., Indiana

Producers of silica sand

American Window Glass Co., Derry (o. b.)
A. C. Bowers & Sons, R. D. 8, Lancaster
Maurice Bowman, Bowmanstown
A. B. Cooper Co., Johnstown
W. M. Cronister, 2520 Beale Ave., Altoona (o. b.)
Derry Glass Sand Co., Derry
Dick Sand Co., Franklin (Polk)
Dunbar Corporation, Dunbar
Falls Creek Sand & Stone Co., Falls Creek
Gardner Sand Co., Ridgway
Greenville Silica Products Co., Greenville
Hunkers Sand & Stone Co., Hunkers
Lewis F. Kemmerer, R. D. 5, Lehighton (Germans)
Leesburg Silica Sand Co., New Castle (Leesburg)
Lycoming Silica Sand Co., Montoursville
Mercer Sand Co., Mercer (Leesburg)
Mercer Silica Co., Mercer
E. F. Millard Sand Works, Shippensburg
J. H. Miller, Burnham
Mt. Cydonia Sand Co., Chambersburg
Pennsylvania Glass Sand Co., Lewistown
J. E. Peterson, Mt. Holly Springs
Pittsburgh White Sand Co., Mapleton Depot
Richland Sand Products Co., 1126 Park Bldg., Pittsburgh (Emlenton)
Silicon Products Co., Daguecahonda
Silica Sand Co., Steelton (Mt. Holly Springs)
Smith & Landis, Mont Alto
Valley Forge Sand Co., Valley Forge
Venango Sand Co., Franklin (Utica)
Welsh Mt. Mining & Kaolin Mfg. Co., 1021 N. Delaware St., Philadelphia (Honeybrook)
Winfield Sand Co., 2215 Oliver Bldg., Pittsburgh (West Winfield)
Youngstown Sand Co., 1106 Wick Bldg., Youngstown (Leesburg)

Producers of core sand or pig bed sand.

Melchoir Braun, 14th & Douglas St., Reading
J. K. Davison Company, Pittsburgh
F. G. Frock, McSherrytown
Gratztown Sand Co., 1507 Kennan Bldg., Pittsburgh (Gratztown)
Keystone Sand Products Co., Lebanon (Jonestown)
F. A. J. Miller, Allentown S. E.
D. N. Thomas Sand & Gravel Co., Williamsport
Walker Sand Co., West Springfield (Fairview)
West Middlesex Sand Co., West Middlesex
R. A. Wood Sand Co., Sharon

PRODUCTION

The following table shows the quantity and value of molding sand of all kinds produced in Pennsylvania and in the United States in the last 10 years.

Molding sand produced and sold in Pennsylvania and in the United States 1916-1925.

year	Pennsylvania			United States		
	Short tons	Value		Short tons	Value	
		Total	Average		Total	Average
1916	737,385	$590,704	$0.80	4,662,649	$3,219,839	$0.69
1917	640,456	696,734	1.09	4,660,968	4,303,809	.92
1918	1,158,715	953,880	.82	4,910,178	5,121,865	1.04
1919	512,862	712,460	1.38	3,774,612	4,153,990	1.10
1920	611,930	1,020,927	1.66	5,128,075	7,504,759	1.46
1921	242,810	384,249	1.58	1,906,977	2,451,966	1.29
1922	428,782	584,650	1.13	3,839,116	4,478,405	1.17
1923	781,389	1,271,174	1.62	5,559,644	6,730,417	1.21
1924	477,087	725,981	1.52	4,403,893	4,905,268	1.13
1925	537,536	792,067	1.47	4,995,428	5,400,618	1.08

The figures representing average value per ton are not of much interest, for the data on which they are based include the quantity and value of very different materials, ranging from washed silica sand to heavy loam, and from 25 cents to $2.00 a ton.

These statistics of production prepared by the United States Geological Survey are of interest as showing the volume of business done by the producers of molding sand or the sum of money spent by foundries each year for sand produced in Pennsylvania. They do not tell the whole story, however, for although some molding sand is shipped out of Pennsylvania, considerable quantities are brought into the Commonwealth, especially from New York and New Jersey. To the original cost of the sand must be added heavy freight charges. A $60.00 car of sand at Albany, New York, may have a $120.00 freight bill attached to it when it reaches a central Pennsylvania foundry.

These statistics are inadequate in that no distinction is made between natural bonded molding sand, washed silica sand, and fine

gravel used for core sand. They show only that so much sand was sold to foundries for molding metal. To be of more value to the foundry industry a statistical report on molding sand should distinguish at least between bonded and unbonded sands.

Pennsylvania is one of the three largest producers of molding sand in the United States. The output in 1923 was more than three-quarters of a million tons, valued at a million and a quarter dollars. And yet when this investigation was undertaken no description of the molding sand resources of the State had ever been published.

The market for this sand is large. There are more than 750 iron, steel, and brass foundries in Pennsylvania.

PURPOSES OF REPORT

The investigation of the molding sands of the Commonwealth was undertaken by the Pennsylvania Geological Survey for the purpose of making available to foundrymen information regarding the character of the molding sands produced in the Commonwealth. The writer knew that many Pennsylvania foundries are using molding sands produced in New York, New Jersey, and Ohio. If this were a case of foundries near the border of Pennsylvania getting sand from just over the border, little would be thought of it, but when a manufacturer of stoves in central Pennsylvania has used a local sand satisfactorily for years and a manufacturer of stoves in western Pennsylvania uses sand from Albany, New York, it is apparent that the information about and confidence in Pennsylvania molding sands is lacking. The anomalous condition exists of a foundry in central Pennsylvania casting radiators in Albany sand with a freight rate of more than $100 a car, and of a western New York foundry casting radiators in sand from central Pennsylvania. The writer was interested to find foundries within a few miles of each other and doing the same kind of general custom work in gray iron castings, one satisfactorily with sand produced less than 100 miles away and the other with sand brought 300 miles.

As the work of collecting samples of Pennsylvania molding sand progressed it became increasingly apparent that foundrymen should be interested in and benefit by standard tests, and the producers of molding sand could use them as selling arguments.

Some and perhaps many of the 750 foundries in the Commonwealth are using sand from a distant source which could be duplicated from a nearer source with a saving in cost of transportation. In order, therefore, to benefit the producers and users of molding sand, the Pennsylvania Topographic and Geologic Survey gladly accepted the opportunity to cooperate with the American Foundrymen's Association and the National Research Council.

METHOD OF INVESTIGATION

Field work. With a list of producers of molding sand from the U. S. Geological Survey the writer began collecting samples in the summer of 1923 as occasion offered. By short trips from Harrisburg in an automobile the localities in the eastern and central parts of the State were visited, and a longer trip in 1924 took me as far as Erie County. In the summer of 1925 the collection of samples was practically completed by visiting producers west of Tyrone and south of Indiana.

Muslin bags of a size suitable for holding 25 and 50 pound samples were used, together with metal identification tags. Sand for testing was dug from the face of pits, from storage bins and stock piles at pits and foundries, and from loaded cars. Pit samples were cut by the writer or by the operator from the face actually being dug or that had last been worked and represent a definite grade that the operator can duplicate on demand. The stock pile, storage bin, and car samples were taken by digging a shovelful of sand from six to ten places in the heap. All the samples were of well mixed material and were shipped to the laboratory in separate muslin bags packed in burlap sacks or barrels.

Laboratory work. The samples were tested under the direction of Professor H. Ries in the laboratory of the Department of Geology, Cornell University, Ithaca, New York, and at the expense of the American Foundrymen's Association. Most of the routine testing was done by laboratory assistants paid by the Association and under the supervision of Professor H. Ries.

The tests made on the sands are those approved by the American Foundrymen's Association, on recommendation of the sub-committee on standard tests of the Joint Committee on Molding Sand. As these tests are made in standardized apparatus and by definitely specified methods, the results are comparable with those of other organizations using the standardized tests, including the U. S. Bureau of Standards, the Engineering Experiment Station, University of Illinois, and the Commerical Club of Cincinnati Resource Survey, University of Cincinnati, Ohio.

All samples were tested for fineness or grain size, bonding strength, and permeability in accordance with the standard methods approved by the American Foundrymen's Association. Samples of all sands also were sent from Ithaca to the laboratory of Saunders and Franklin, at Providence, R. I., where dye adsorption tests were made through the courtesy of W. H. Saunders. As a description of these tests is not readily available to all who may be interested in this subject, they are repeated here.

STANDARD TESTS OF MOLDING SAND

Any foundry that buys so much molding sand that its cost is a noticeable part of the expense of casting, has need for a means of making an accurate test of molding sand. At least three reasons make testing desirable.

1. The properties of the sand in daily use on the molding floor should be kept within certain limits of variation to assure good castings.

2. Before unloading a new shipment of sand from the regular source of supply it should be tested to see that it conforms to standards.

3. Sand from a new source of supply may be tested for comparison with the sand in regular use.

The standardized tests for fineness, bond-strength, permeability, and dye adsorption are quoted from the American Foundrymen's Association bulletin, and were used for all samples.

STANDARD FINENESS TEST

50 grams of molding sand, dried for at least 1 hour at a temperature which shall not be lower than 105 degrees Centigrade nor higher than 110 degrees Centigrade, are put into a 1-quart milk bottle[1] or preserving jar, smooth on the inside, with no sharp shoulders in the neck, to permit the sand to be easily removed with a small stream of water. 475 cubic centimeters of water and 25 cubic centimeters of a standard solution of sodium hydroxide (made by dissolving 10 grams of sodium hydroxide in 1000 cubic centimeters of water) are added, and the bottle or jar is covered and securely sealed. In using a preserving jar, instead of the usual rubber ring, a rubber disc is employed, which fits into the inside of the glass cover. The receptacle is then placed in a shaking machine, about 60 revolutions per minute, in such a manner as to allow it to be up-ended at each revolution. At the end of 1 hour the receptacle is removed, the cover is unsealed, and the sand adhering to the cover is washed into the receptacle. The receptacle is then filled with water,[2] permitting the stream to stir up the contents, and allowed to stand for 10 minutes, when by means of a siphon extending to within 2.5 centimeters (approximately 1 inch) of the bottom of the receptacle, the water is siphoned off. More water is added, filling the receptacle, and at the end of 10 minutes siphoned off. Water is added again, and at the end of 5 minutes siphoned off. The process of 5 minutes standing and siphoning is repeated until the water remains clear at the end of the 5-minute period. By this means the clay substance is separated from the grain, and may be collected in suitable containers and recovered by the addition of acid to neutralize the sodium hydroxide.

The grain remaining in the bottle or jar is washed onto a filter-paper, in a 9-centimeter Buchner's funnel, is transferred, together with the filter-paper, to a large glass, and dried for ½ hour at a temperature which shall not be lower than 105 degrees Centigrade nor higher than 110 degrees Centigrade. The dried grain is weighed, and the difference between its weight and that of the original 50-gram sample is ascertained to determine the clay substance.

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[1] The Sub-Committee recommends the use of a standard quart preserving jar filled to the base of the neck, and eliminates the milk bottle.

[2] At my works we used the clay to flocculate and settle before the latter could be siphoned off. It was found necessary to use water free of positive electrolyte, such as distilled water or power-plant boiler water.

The grain is then placed on the first of a series of sieves, U. S. Bureau of Standards Nos. 6, 12, 20, 40, 70, 100, 140, 200 and 270. These sieves are placed in a Rotap testing-sieve shaker,[1] or other machine the use of which may yield identical results. This machine is run for 15 minutes, and the amount remaining on each sieve is weighed, and expressed in percentage. The portion passing the No. 270 sieve is known as "No. 270 minus," or "—270 mesh."

Series of sieves, United States Bureau of Standards.

Sieve number	Sieve opening		Wire diameter		Tolerance			
					In average opening	In wire diameter		In maximum opening
	Millimeters	Inches	Millimeters	Inches	Per cent	Per cent		Per cent
6	3.36	.132	1.02	.040	3	—15	to —20	10
12	1.68	.0661	.69	.0372	3	—15	to —20	10
20	.84	.0331	.42	.0235	3	—15	to —20	5
40	.42	.0165	.25	.0098	5	—25	to —30	25
70	.210	.0083	.142	.0055	6	—15	to —30	40
100	.149	.0059	.102	.0040	6	—15	to —35	40
140	.105	.0041	.074	.0028	8	—15	to —35	60
200	.074	.0029	.053	.0021	8	—25	to —35	60
270	.053	.0021	.041	.0016	8	—15	to —35	50

STANDARD BOND-STRENGTH TEST

Tempering of Sand

1. The sample to be tested should be an average one, representative of the heap, floor, car, bank, or other source from which it is taken.

2. In testing sand for cohesiveness it is absolutely necessary that the sand be properly sampled and uniformly tempered. For plant check or control tests upon facing or heap sands in daily use, one may test the sand as tempered for molding.

3. Since it is the object to determine the maximum cohesiveness under suitable foundry working conditions, in the examination of new sands experiment should invariably be made with several water contents in order to ascertain that amount (optimum water content) which develops the maximum degree of cohesiveness. It is advisable in most cases to try percentages of water beginning with 4 per cent and increasing by stages of 2 per cent, up to and including at least 8 per cent. Sometimes it will be found difficult to make a test with a water content of an exact predetermined percentage. The permissible extent of deviation from the predetermined amount should in no case be more than one-half per cent, and can be determined intelligently by the careful experimenter who observes critically the tendency of a sand to show widely differing cohesiveness values as the water content is appreciably changed. A deviation not exceeding .2 per cent (5.8 per cent or 6.2 per cent in the case of an attempt to get 6 per cent) can be considered as entirely satisfactory for the determination of the cohesiveness at the nearest fixed percentage. The exact percentage of moisture, even if within .2 per cent, should be reported. Supplementary tests with lower percentages of water than 4 per cent and higher percentages than 8 per cent should be made if and when the facts ascertained justify such tests. For example, when a permeability value considered proper to report is obtained on a sand with a moisture content below 4 per cent or above 8 per cent and a cohesiveness value on the sand is desired, the test for cohesiveness should be conducted with the

[1] Manufacturers of equipment used in making Standard Tests are listed in the American Foundrymen's Association bulletin.

sand tempered with the same amount of water as in the case of the permeability test. In such cases, a sufficiently large sample of sand should be tempered, to permit making both of these tests.

4. In the examination of new sands, proceed as follows: Dry 1000 grams of sand, selected according to the directions for sampling molding sand, for one hour at a temperature not below 105 degrees Centigrade, nor above 110 degrees Centigrade. Care should be exercised to spread the sand over a large area in a thin layer in order to expel all the moisture in a given time. This will make it possible to add the proper amount of water and give the sand the desired moisture content.

5. After the sand has cooled, measure out the desired quantity of water, adding sufficient extra water (usually from one-fourth to one per cent) to allow for evaporation during mixing. Thus if it is desired to add 4 per cent water and one-half per cent extra water is needed, one would add 47 cubic centimeters (since one cubic centimeter of water weighs 1 gram) to 1000 grams, and secure a total weight of 1047 grams.[1]

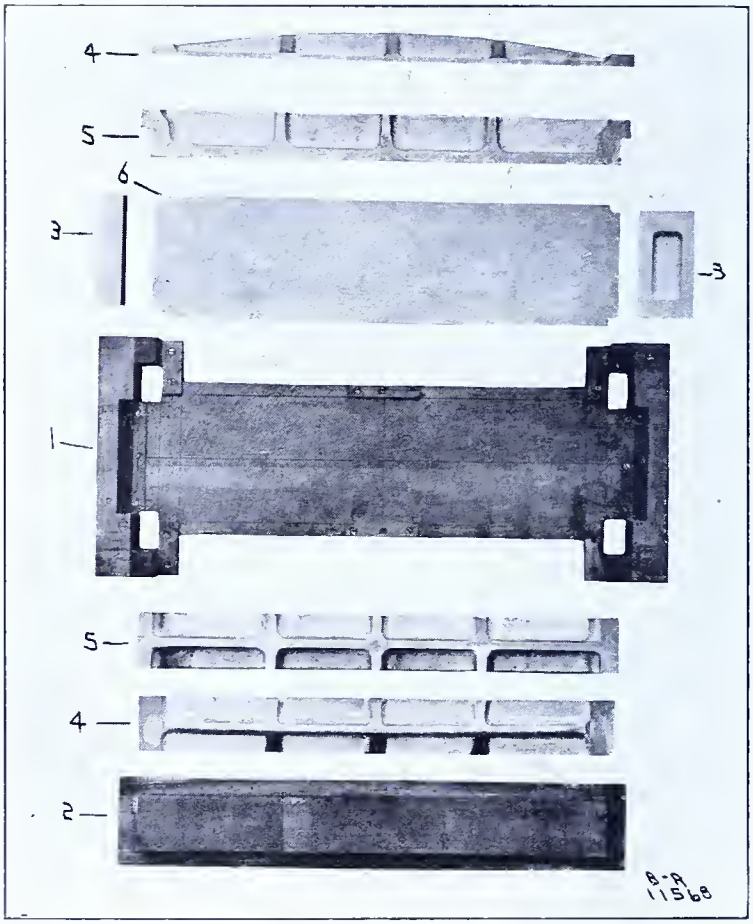

Plate I. Mold box parts for bond test.

6. For the tempering operation, spread the sand on a smooth flat dry surface in a layer about 1 inch thick, sprinkle a small quantity of the required water evenly over the sand, and work the latter gradually into a heap by rubbing it vigorously through the hands. Again spread it into a thin layer and repeat

[1]Moisture content for all molding sand determinations and tests is to be expressed as the percentage of moisture in the damp sample of sand. It is not proper to calculate the amount of moisture, proportionate to the weight only of the dry sand.

the above operations, adding more water. Continue to do this until all of the water has been thoroughly distributed through the sand. There should be no dry lumps or other evidence of uneven tempering.

7. The sand should now be allowed to stand in order that the maximum temper may be developed. To secure this temper, place the sand in a humidor or air-tight receptacle and allow it to stand for 24 hours. After this, the sample is ready to be tested, as below.

8. Take the entire sample of sand from the humidor. Pass this entire sample twice through a coarse riddle and return the sand as quickly as possible to the humidor or receptacle. From this take sample to be tested for cohesiveness; also sample to be tested for moisture content, and for permeability if desired.

Ascertaining Moisture Content

9. The moisture content is to be determined as follows: Dry 100 grams of tempered sand for one hour between 105 degrees and 110 degrees Centigrade. When dry re-weigh. The loss of weight in grams is the moisture content expressed as percentage.

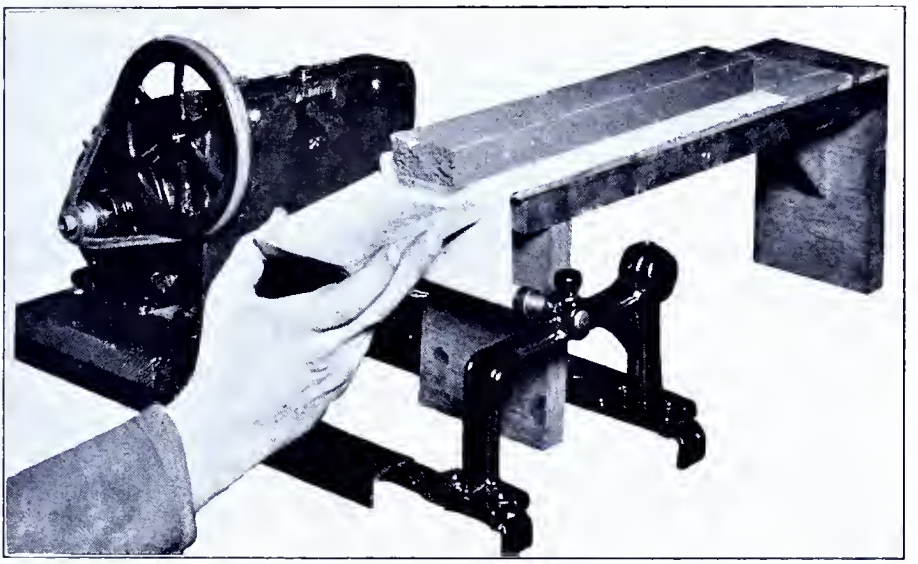

Plate II. Constant-speed motor pulling device for breaking bond test bars.

Method of Procedure in Testing for Cohesiveness

10. While the sand is drying remove all loose pieces from the box as shown in Plate I. Replace metal plate (No. 6, Plate I) in frame (No. 1), locating the plate between the small projections on the bottom of the frame; and upon this plate[1] place a piece of thin waxed or oiled paper which is of the same width as the end of the plate, but long enough to be inserted in the slotted shaft of the motor-pulling device (Plate II). One end of the strip of paper should be even with one end of the plate, and the other should project and be turned around the other end of the plate, so as to lie smoothly against its under side. Replace sections 5 (Plate I), moving them as far toward the outer edge of the frame as is possible. Then replace sections 3 (Plate I). Place the open box directly beneath the riddle which is shown together with the box and strikes in Plate III.

11. Take a sufficient quantity (approximately 1000 grams) of tempered sand to make a bar one inch thick, with a tolerance of not more than three per

[1]The metal plate can be made of aluminum, brass, or of some other non-corrosive metal. The light weight of aluminum makes it preferable for handling.

cent. Place the weighed sand and some tumbling stars in the riddle, and shake until the sand has passed through it.[1] Remove the box from beneath the riddle, and brush all particles on top of sides of box, into same.

12. Level off the sand in the box by using the strikes shown in Plate IV. In striking off, it is important to start with that strike which grazes the highest level of the sand, working from the center alternately toward the ends of the box, and swinging the strikes around as the ends are approached, so that no sand will be packed between the strike and the end of the box. Continue the use of strikes consecutively deeper by 1/16 inch until a uniform level of sand is obtained throughout the box.

13. Starting with section 5 on one side of the box, push it toward the center as far as possible, and hold in position by inserting section 4 (Plate V). Repeat this operation on opposite side.

14. Place the trussed rammer (Plate III) in a level position on the sand in the box. Place the box with the trussed rammer in an impact machine similar

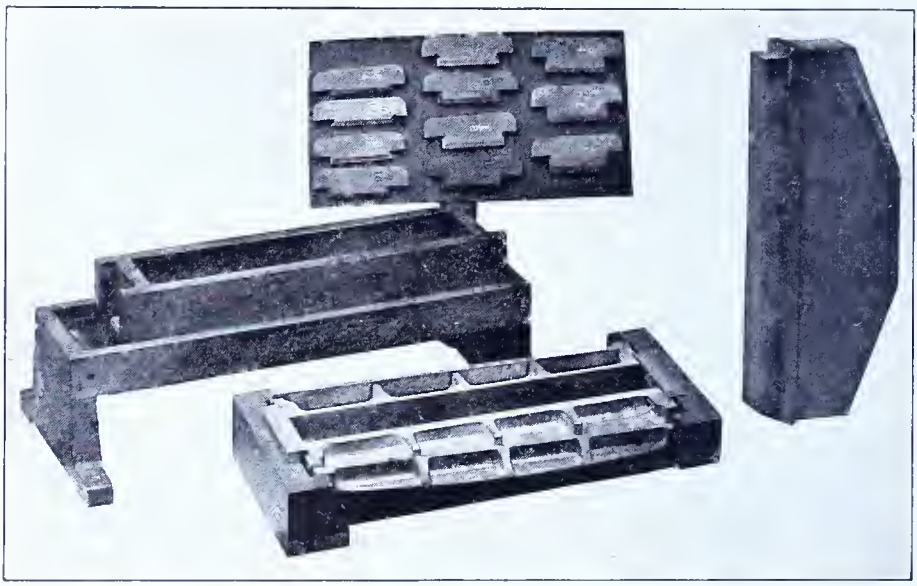

Plate III. Assembled mold box, screen, and rammer block for bond test.

to that shown in Plate X, so that the weight will fall on the center of the truss. Drop a twenty-pound weight three times from a height of sixteen inches.

15. Remove box with trussed rammer from impact machine. Then remove trussed rammer and section 4, 5 and 3 in the order named. In removing section 3 be especially careful to push it away from the bar as it is being lifted.

16. Remove metal plate supporting the bar lying on the paper. With a scale divided into hundredths of an inch, measure both sides of the bar at three points to determine the average thickness, considering the inch to be the unit of thickness. The thickness should be uniform, but experiments have shown that variations in thickness do not appreciably affect the results when the deviations in the thickness of the bar do not vary from the prescribed one inch dimension, over or under, at any point, by more than .02 inch. Set the plate carrying bar and paper on the table of breaking apparatus (Plate II), with one end of the plate

[1] In the case of some coarse sands like Millville gravel there is a tendency for the finer particles to go through the screen of the riddle first, the coarser particles and pebbles passing through later. This tends to give a layered structure to the bar, which is undesirable. Where the sand shows such a tendency the use of a coarser screen in the riddle for feeding the material into the box is permissible. Revised instructions omit the use of the riddle box and read: "Take a sufficient quantity (approximately 1000 grams.) of sand, mix by hand, and transfer carefully into mold box with minimum ramming effect."

projecting about one-half inch beyond the end of table. The free end of the paper should extend from the projecting end of the plate, and should pass through the slot in the shaft of the motor-pulling device (Plate II).

17. Start the motor-pulling device,[1] which draws the bar forward at the rate of six inches per minute. When the weight of the overhanging section causes a portion of the bar to break off, stop the motor. Catch the portion breaking off in some convenient receptacle (as illustrated in Plate II) which has been

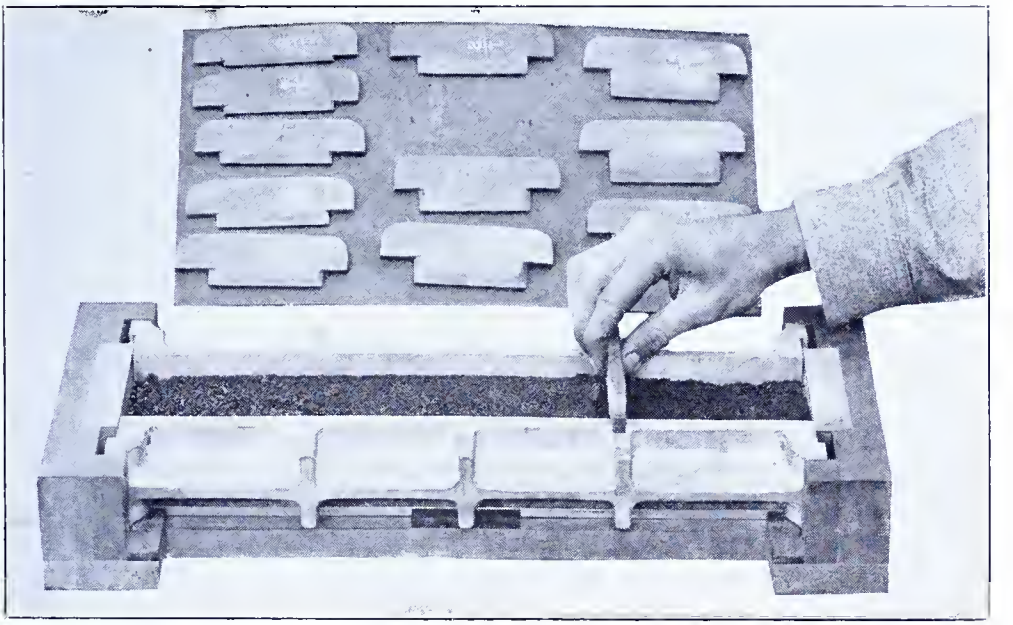

Plate IV. Method of leveling sand in mold box using graduated strikes of graduated depth.

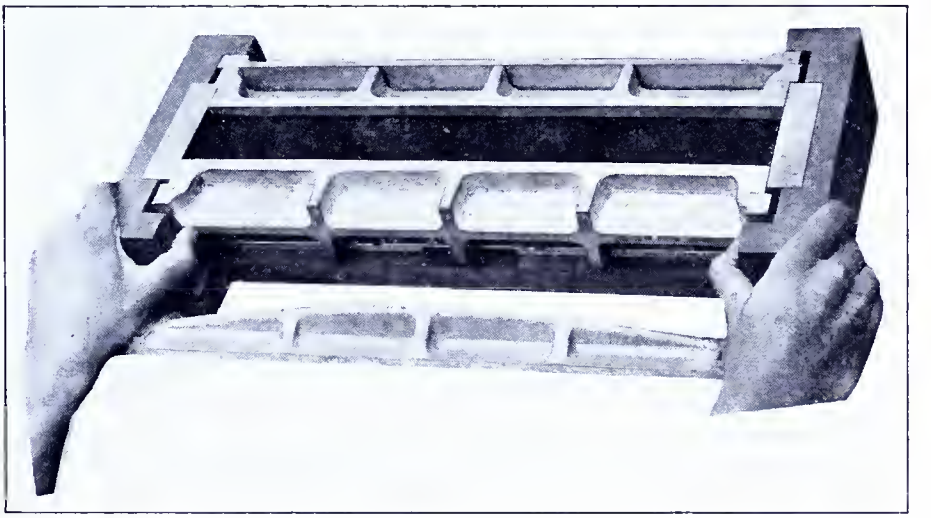

Plate V. Method of assembling mold box after sand has been riddled in box.

[1]Instead of the motor-pulling device illustrated, any suitable form of apparatus may be used, which employs power geared to a shaft in such ratio that the said shaft to which the paper is attached will be revolved at a constant speed to draw the bar at six inches per minute. A steady forward movement of the bar for each break is imperative. For intelligent comparison of results a uniform pulling speed, to be employed by all operators, is necessary. A speed of six inches is adopted because it has been found satisfactory with weak and strong sands.

previously weighed. This receptacle may be a piece of thin metal which has been bent into a shape similar to a bowl or scoop so as to safeguard the catching of every particle of sand as it falls. Weigh the receptacle and every particle of the broken portion of the bar together, and deduct the weight of the receptacle.

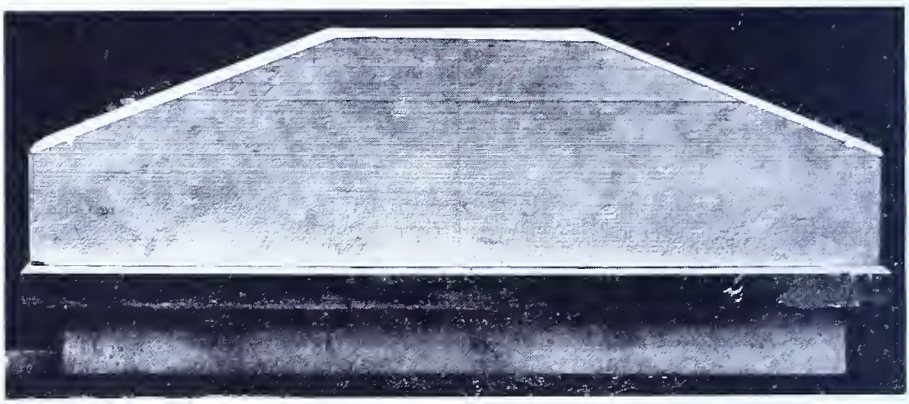

Plate VI. Rammer block for bond test.

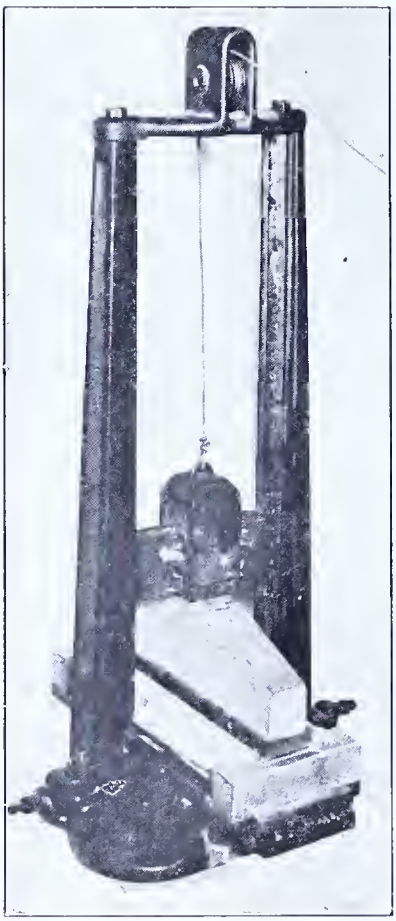

Plate VII. Ramming apparatus for compressing sand in mold box for bond test.

Repeat the operation until as many breaks are obtained as the bar will yield. To prevent the last part of the bar from tilting a broad flat weight of proper size may be placed on the end of the bar to hold it down.

Disposition of Results from Tests

18. If the bar breaks into portions of fairly uniform weights, all breaks may be retained. If the first break differs by more than 10 per cent from the average weight of the others, discard it. Appreciable variations between the weight of the first break and those of the other breaks may be due to the influence on certain sands of close contact with the end piece of the box (No. 3, Plate I). Should the weight of any break other than the first differ from the average weight of the others by more than 10 per cent, discard the entire bar. This difference is usually traceable to improper mixing of the sand or careless use of strikes.

19. Add the weights of all broken sections (except any which may have been discarded) and divide by the number of these. This gives the average breaking weight for a bar of the thickness used. Repeat this operation, until at least six breaks have been obtained from not less than two bars, and average the results of the average breaks from each bar. If properly carried out, the test of the number of bars as specified should yield an average from which no individual bar should vary more than 5 per cent. Failure to meet this requirement indicates faulty manipulation.

20. The bonding strength is to be expressed in terms of the actual weight in grams of the average breaking strength of the bar, including moisture.

Example A

Bonding Strength$=213.6\times100\div500=213.6\div5=42.7$ per cent

Example B

Bonding Strength$=252.9\times100\div500=252.9\div5=50.6$ per cent

21. Having completed the test on samples with varying moisture contents, report the bonding strength or cohesiveness of each, with its corresponding moisture content.

STANDARD PERMEABILITY TEST

Permeability Apparatus.

The parts[1] of the permeability apparatus are as follows: Tank A (Plates VIII and IX) is made of copper, tin lined, and is provided with a vertical air outlet tube coming up through the bottom of the same. When in use this tank is partly filled with water, as will be described later. A stop-cock is provided on the side of tank A at the bottom, to drain off the water when the apparatus is not in use, or when adjusting the water-level. Bell B has a vertical tube (C-1, Plate IX) which slides inside the air outlet tube (C-2, Plate IX) in tank A. Near the top of this tube are several vents to permit the air to be forced out of bell B. A three-way valve D (shown assembled in Plate VIII) is attached to the lower end of the outlet tube from tank A. The opening in the valve should not be too small, preferably not less than .12 square inches (3 square millimeters), so as to permit the air to pass through freely. The parts of this valve are shown as D1 to D4, inclusive (Plate IX). A valve-indicator, D3, is provided, marked "On," "Off," and "Vent," to show when the valve is in position to let air from bell B through sand in sand container E; to shut off flow of air from bell; or to permit air to enter by-pass while raising the bell. A nipple G, over which fits a rubber stopper H, which is held in place by two lock-nuts I and J, is attached to the lower side of the valve. An orifice-plate K for use in rapid work, is screwed into the lower end of the nipple G. One of

[1]Dimensions of the different parts are given on the parallel perspective drawing (Plate IX).

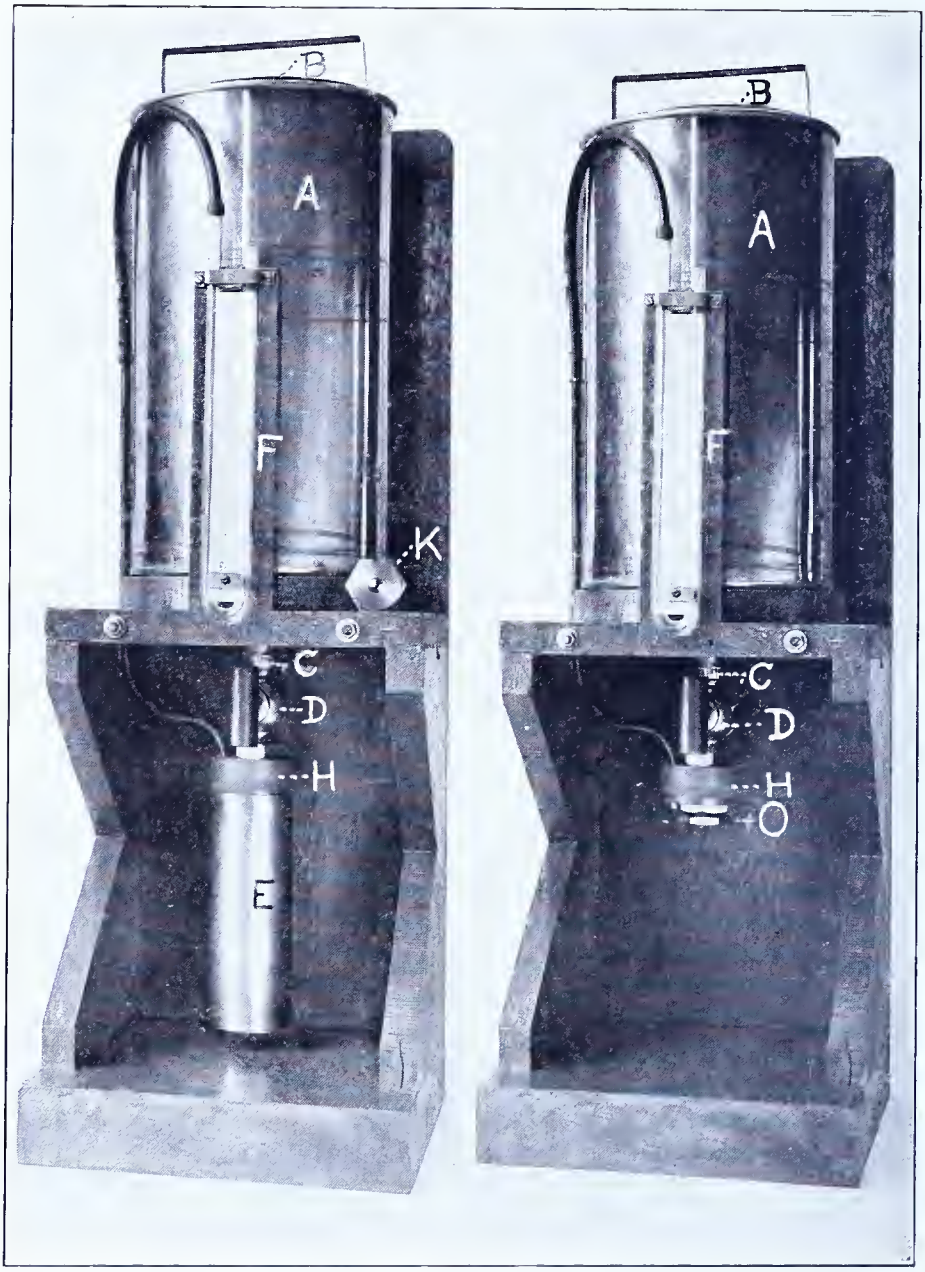

Plate VIII. Permeability testing apparatus. The apparatus on the left has a sand container (E) in place ready for testing.

the orifice-plates can be seen on the shelf at base of tank (Plate VIIIK). The rubber stopper H fits into a sand container E. In front of the tank A, there is a manometer F, having a scale divided into centimeters and millimeters. This connects with a brass tube that passes down through the rubber stopper H. All parts are of brass, except those described as being made of other materials, and except the stand or base.

As the bell B sinks into the water in tank A, it forces air into the outlet pipe C-1 (Plate VIII) through the valve D and through the sample of sand packed in the container E. The pressure of this air is read on the manometer F. Since the pressure recorded on the manometer depends on the weight of the bell B,

and on its cross-sectional area, the weight should be made such as to give a pressure of about, but not less than 1.1 ounce per square inch (5 grams per square centimeter).[1] There should also be a weight provided, which can be placed on top of bell B, sufficient to increase the manometer pressure reading to 10 centimeters. This latter pressure is more convenient for testing very fine sands and for rapid work. An easily graduated weight is a bag of shot.

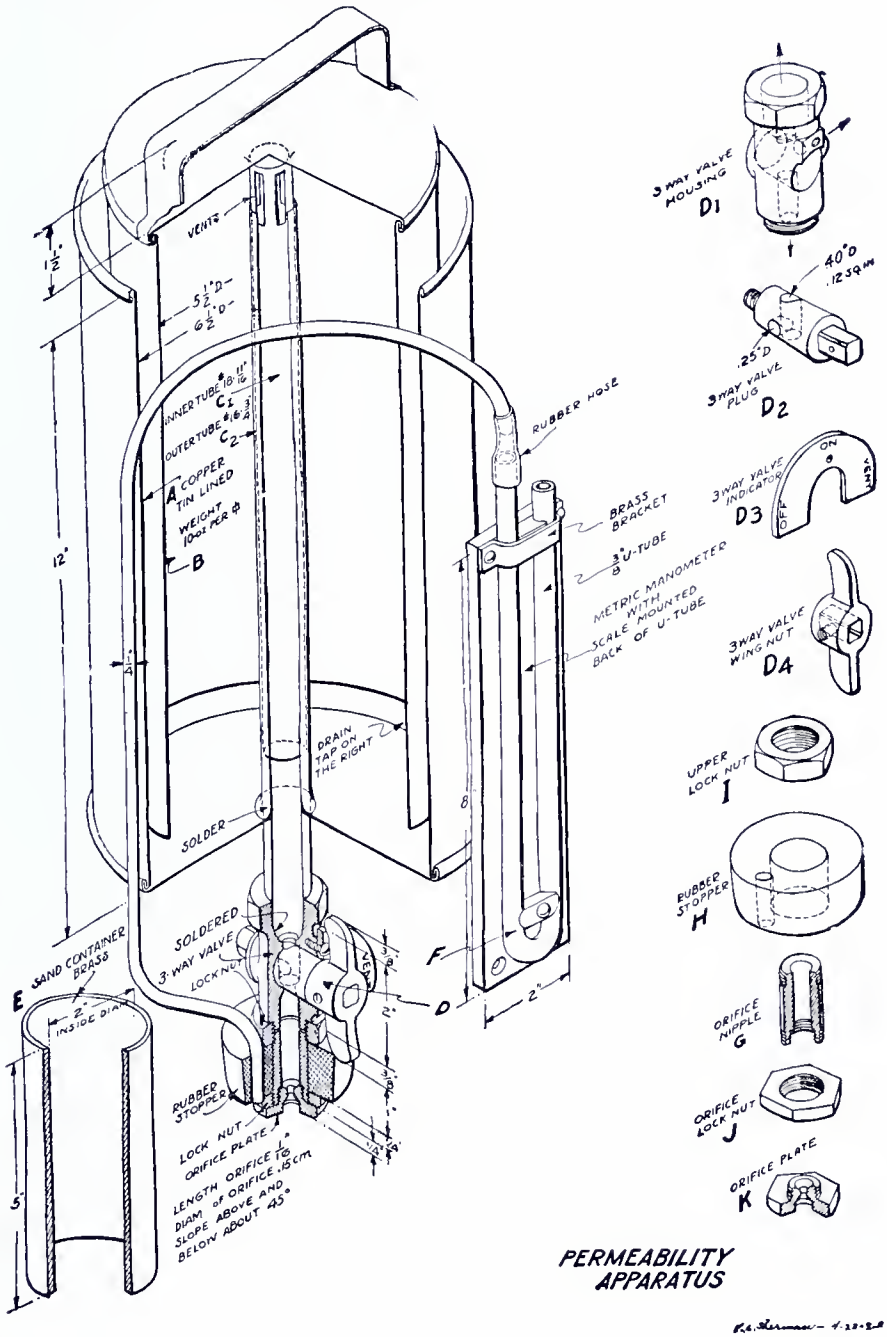

Plate IX. Perspective drawing of permeability testing apparatus.

[1] If less than 5 centimeters pressure is recorded the bell sinks too slowly when a very fine sand is being tested. The amount of pressure can be determined by attaching the empty sand container to the apparatus, plugging its lower end with a cork, and opening the valve.

The bell B has several lines marked on it, the lowest being "X," the second "O," the next "1000" and the fourth "2000." These indicate that the capacity of the bell between the "O" and "1000" marks is 1000 cubic centimeters (61 cu. in.), and between "O" and "2000" it is 2000 cubic centimeters (122 cu. in.).

The object of having the mark "X," which is about $\frac{3}{4}$ inch (19 millimeters) below the zero mark, is to insure raising the bell to the proper height, so that when it is necessary in a standard test to read the time required for the bell to sink from zero to 1000 or 2000, the zero mark will be clearly visible.

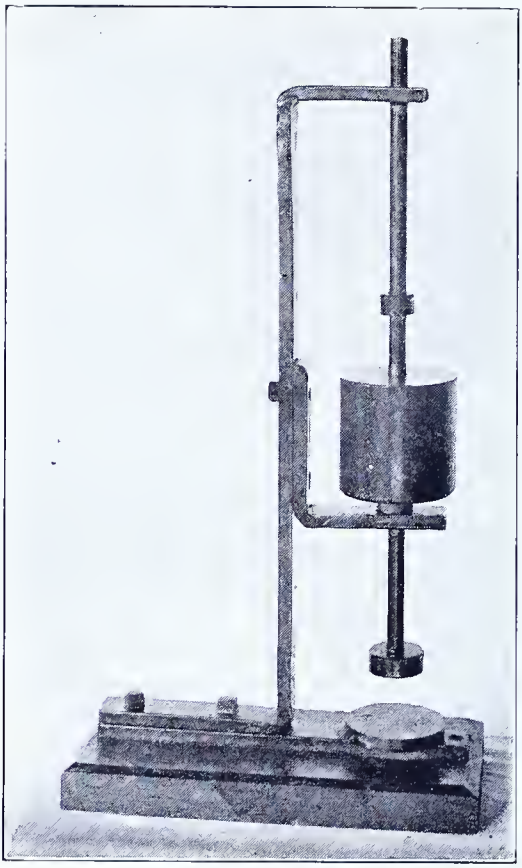

Plate X. Ramming device for permeability test.

To raise the bell, turn the indicator on valve plug to "Vent" (Plate IX). This allows air to enter through the by-pass instead of having to be drawn through the sand. Then turn indicator to "Off," and the bell will remain in its raised position. When ready to start the test, turn indicator to "On," and the bell will sink as air is forced through the valve.

The sand container E (Plate VIIIA) is a brass cylinder 5 inches (12.70 centimeters) high and 2 inches (5.08 centimeters) inside diameter.

The sand rammer is shown in Plate X (Detailed drawings omitted). It consists of a steel rod, supported by two guides. A steel disc is attached to the lower end of the rod, and has a sliding fit in the sand container E (Plate VIIIA). A cast iron rammer head, weighing 14 pounds (6350.36 grams), slides on the rod, its movement being regulated by two stops. The distance between these stops is sufficient to permit a 2 inch (5.08 centimeters) movement of the rammer-head. A pedestal is provided on which the sand container E rests while sand is being placed in it; and while the ramming operation is being performed . This pedestal is shown in Plate X.

On top of the upper steel guide is attached a scale with 3 lines marked on it. If the upper end of the rammer rod is between the upper and lower of these

lines after the third ram, it indicates that the sand sample is within the allowable limits of thickness.

If dry sand is to be tested, a special cap having a 20-mesh brass screen bottom should be used, to slip over the end of the sand container. For ramming dry sand the pedestal can be placed upside down under the container. This supports the screen during ramming, and keeps the sand sample at proper height to use the tolerance marks as a guide.

Preparation of Sample

The sample to be tested should be an average one, representative of the heap, floor, car, bank or other source from which it is taken.

Tempering of Sand

In testing sand for permeability it is absolutely necessary that the sand be properly sampled and uniformly tempered. For plant check or control tests upon facing or heap sands in daily use, one may test the sand as tempered for molding.

Since it is the object to determine the maximum permeability under suitable foundry working conditions, in the examination of new sands experiments should invariably be made with several water contents in order to ascertain that amount (optimum water content) which develops the maximum degree of permeability. It is advisable in most cases to try percentages of water beginning with 4 per cent and increasing by stages of 2 per cent, up to and including at least 8 per cent. Sometimes it will be found difficult to make a test with a water content of an exact predetermined percentage. The permissible extent of diviation from the predetermined amount should in no case be more than one-half per cent, and can be intelligently determined by the careful experimenter who observes critically the tendency of a sand to show widely differing permeability values as the water content is appreciably changed. A deviation not exceeding .2 per cent (5.8 per cent or 6.2 per cent in the case of an attempt to get 6 per cent) can be considered as entirely satisfactory for the determination of the permeability at the nearest fixed percentage. The exact percentage of moisture, even if within .2 per cent, should be reported. Supplementary tests with lower percentages of water than 4 per cent and higher percentages than 8 per cent should be made if and when the facts ascertained justify such tests. For example, when a cohesiveness value considered proper to report is obtained on a sand with a moisture content below 4 per cent or above 8 per cent and a permeability value on the sand is desired, the test for permeability should be conducted with the sand tempered with the same amount of water as in the case of the cohesiveness test. In such cases, a sufficiently large sample of sand should be tempered to permit making both of these tests.

In the examination of new sands, proceed as follows: Dry 1000 grams of sand, selected according to the directions for sampling molding sand, for one hour at a temperature not below 105 degrees Centigrade nor above 110 degrees Centigrade. Care should be exercised to spread the sand over a large area in a thin layer in order to expel all the moisture in a given time. This will make it possible to add the proper amount of water and give the sand the desired moisture content.

After the sand has cooled, measure out the desired quantity of water, adding sufficient extra water (usually from one-fourth to one per cent) to allow for evaporation during mixing. Thus if it is desired to add 4 per cent water and one-half per cent extra water is needed, one would add 47 cubic centimeters (since one cubic centimeter of water weighs 1 gram) to 1000 grams, and secure a total weight of 1047 grams.[1]

[1]Moisture content for all molding sand determinations and tests is to be expressed as the percentage of moisture in the damp sample of sand. It is not proper to calculate the amount of moisture, proportionate to the weight only of the dry sand.

For the tempering operation, spread the sand on a smooth flat dry surface in a layer about 1 inch thick, sprinkle a small quantity of the required water evenly over the sand, and work the latter gradually. Again spread it into a thin layer and repeat the above operations, adding more water. Continue to do this until all of the water has been thoroughly distributed through the sand. There should be no dry lumps or other evidence of uneven tempering.

The sand should now be allowed to stand in order that the maximum temper may be developed. To secure this temper place the sand in a humidor or air tight receptacle, and allow it to stand for 24 hours. After this, the sample is ready to be tested, as below.

Take the entire sample of sand from the humidor. Pass this entire sample twice through a coarse riddle and return the sand as quickly as possible to the humidor or receptacle. From this take sample to be tested for permeability; also sample to be tested for moisture content, and for cohesiveness if desired.

Ascertaining Moisture Content

The moisture content is to be determined as follows: Dry 100 grams of tempered sand for one hour between 105 degrees and 110 degrees Centigrade. When dry re-weigh. The loss of weight in grams is the moisture content expressed as percentage.

Ramming of Specimen

Take a sufficient quantity (from 150 to 200 grams) of tempered sand to make a column 2 inches (5.08 centimeters) high, with a tolerance of 4 per cent. The sand should be carefully placed in the container E, and gently leveled off. Place pedestal and container with sand in position beneath rammer. Gently lower rammer-rod with head into container until they are supported by the sand. Raise rammer-head to the upper stop, and let fall. Repeat twice, making a total of 3 rams. Note whether the upper end of the rod is within the tolerance marks. If not, discard the sample and put in another lot of tempered sand of sufficient quantity to yield a column of the required height. This is usually accomplished on the second trial. Lift rammer-rod until disc at lower end of rod is free from the sand container, and take container off pedestal.

Measurement of Air Flow

Fill tank A with water to within $4\frac{3}{4}$ inches (12.2 centimeters) of the top. Before attaching sand container with specimen, open valve D, and raise bell B until mark "X" appears. Then close valve D. Attach sand container to rubber stopper H, moistening sides of stopper before applying, to prevent air leakage. Open valve D. Note scale on side of bell B, and as cup sinks, and zero mark on scale passes edge of tank A, start stop-watch. Read pressure in manometer tube as soon as the pressure reading becomes steady. The instant the "2000" mark on bell B reaches upper edge of tank A, the stop-watch should be stopped and time recorded. This represents the time required to force 2000 cubic centimeters of air through the sand. The time and pressure obtained as above, are to be used as described in the following paragraphs.

Calculation of Permeability

The degree of permeability as determined by this test is found by employing a formula. By its use, permeability is ascertained as the volume of air per minute, per gram per square centimeter pressure, per unit volume in specimen.

Permeability equals the number of cubic centimeters of air forced through the sand specimen, mutiplied by the height of the sand specimens in centimeters; and this product divided by the product of the pressure in grams, the area of the sand specimen in square centimeters, and the time in minutes. Thus

$$\text{Permeability} = \frac{\text{cm}^3 \text{ of air} \times \text{cm height of specimen}}{\text{grams pressure} \times \text{cm}^2 \text{ area of specimen} \times \text{minutes}}$$

The method of conducting the permeability test herein described calls for 2000 cubic centimeters of air to be forced through the specimen: 5.08 centimeters (2 inches) to be the height of the specimen; and 20.268 square centimeters (3.1416 sq. in.) to be the area of the specimen. These fixed quantities are therefore substituted as constants in an equation as follows:

$$\text{Permeability} = \frac{2000 \times 5.08}{20.268 \times \text{grams pressure} \times \text{minutes}}$$

Reduced to its simplest terms this equation reads:

$$\text{Permeability} = \frac{501.2}{\text{grams pressure} \times \text{minutes}}$$

STANDARD DYE ADSORBTION TEST

Procedure

1. Twenty-five grams of molding sand, dried for 1 hour at a temperature which shall not be lower than 105 degrees Centigrade nor higher than 110 degrees Centigrade, are weighed into a 500 cubic centimeter wide-mouth bottle fitted with a glass stopper, and 300 cubic centimeters of distilled water, plus 5 cubic centimeters of 10 per cent ammonium hydrate, are added. The bottle is then stoppered, sealed with paraffin wax, and rotated in a suitable machine for 30 minutes (any machine such as that used in the Standard Fineness Test, making approximately 60 revolutions per minute and up-ending the bottle with each revolution, is satisfactory). At the end of this period 90 cubic centimeters of distilled water are added, plus 5 cubic centimeters of 10 per cent acetic acid. Crystal violet dye is then added in sufficient weight to allow for the adsorption by the colloidal matter and leave a slight excess. For molding sands of weak bond, 0.125 grams of dye is a good amount to start with; while the stronger sands require an addition of 0.150-0.300 grams or more of dye. After adding the crystal violet the bottle is sealed again and rotated for another 30 minute period. If all the dye is taken up by the colloidal matter, more should be added, as is it necessary that an excess of dye be present over that required to satisfy the adsorption capacity of the colloids.

2. In order to determine the amount of dye adsorbed by the sand it becomes necessary to find the quantity unadsorbed or held in solution. If the test is allowed to stand over night, suspended material settles out, leaving a clear solution of the dye, and the dye unadsorbed can be determined by color comparison. The standard color solution is made up by dissolving 0.500 grams of crystal violet in 500 cubic centimeters distilled water. Twenty-five cubic centimeters of the clear dye solution are taken from the test by a pipette and run into one of a pair of "carbon" comparison tubes, such as are used in steel analysis (as shown in the illustration of a colorimeter, Plate XI), diluted to 50 cubic centimeters and thoroughly mixed. Forty cubic centimeters or more of distilled water are added

to the second comparison tube, and the standard dye solution added from a burette until the color matches that of the test in question, taking care that the final volume is the same in both tubes. If it required 2.5 cubic centimeters (0.0025 grams) in the standard tube to match the color in the test, then we have 0.0025 grams of dye unadsorbed in 25 cubic centimeters or 0.040 grams in 400 cubic centimeters. This figure is substracted from the amount of dye added to the test, multiplied by 4, and the result expressed as milligrams of dye adsorbed per 100 grams of sand.

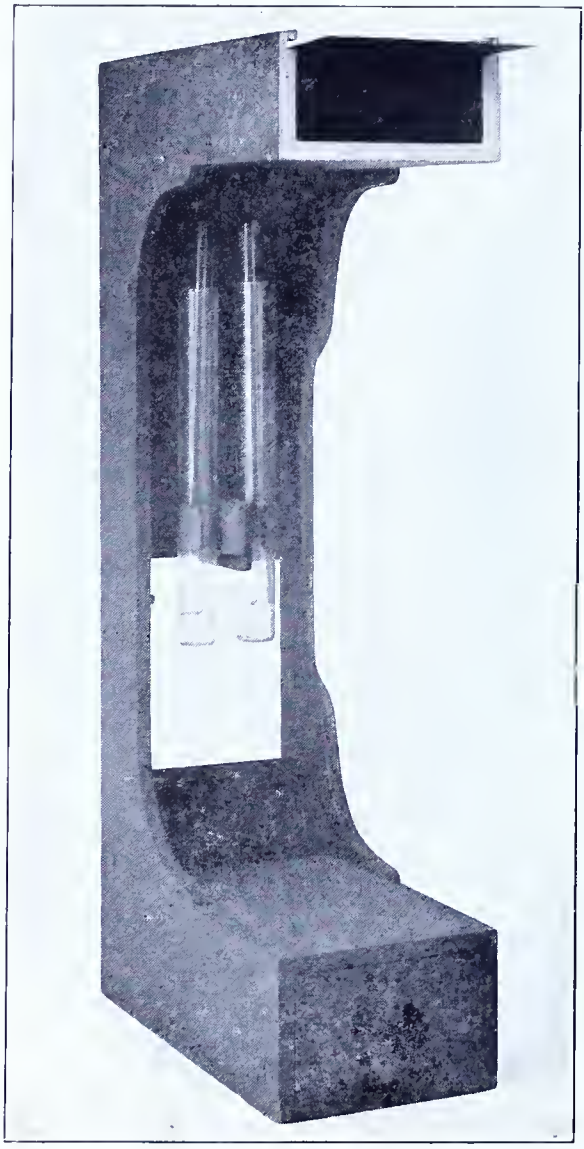

Plate XI. Color comparison tube holder with tubes in place.

Notes

Electrolyte. The presence of ammonium acetate in the test is helpful in that its presence tends to bring about rapidly the subsidence of the fine particles which otherwise would remain in suspension. It has no serious effect on crystal violet. The addition of ammonium hydrate acts as a partial deflocculator and thereby breaks up the agglomerations of clay or other bonding substances.

Dye. Only the highest grade of crystal violet should be used. Impure dye gives low figures and is unstable. Standard dye solution should be kept in the dark, and a fresh quantity should be prepared frequently.

Used Sands. The dye adsorption test cannot be relied upon for all grades of used sands. Impurities present in some heap sands, as for example, sea-coal, iron scale, organic binders, etc. seriously affect the adsorption results.

Dye Concentration. The final concentration of crystal violet should be not less than 0.024 grams, or more than 0.060 grams, in 400 cubic centimeter volume. A greater excess of dye gives high reading. After making a few tests it is a simple matter to judge the density of the clear dye solution, and it is essential that the proper concentration is obtained before the test settles overnight.

GRADING BY GRAIN FINENESS AND CLAY CONTENT

The sub-committee on grading proposes the following method for grading sand with respect to grain size and clay content.

Grain Fineness.

The grain fineness of a sand is approximately the number of mesh per inch of that screen which would just pass the sample of sand if its grains were averaged in size. It is approximately proportional to the surface area per unit weight of a sand, exclusive of clay.

To determine the grain fineness, make the standard A. F. A. fineness test by removing the clay and screening the grain. Multiply the weights or percentage of sand on the various screens by the appropriate factors listed below. Add the products. Divide by the sum of the weights or percentages. The dividend is the A. F. A. grain fineness.

MULTIPLIERS

On 6 mesh, multiply by	3	On 100 mesh, multiply by	70
On 12 mesh, multiply by	5	On 140 mesh, multiply by	100
On 20 mesh, multiply by	10	On 200 mesh, multiply by	140
On 40 mesh, multiply by	20	On 270 mesh, multiply by	200
On 70 mesh, multiply by	40	On pan multiply by	300

Example. Laboratory No. 624.

On 6 mesh	0	× 3	=	0
On 12 mesh	2.08	× 5	=	10.40
On 20 mesh	8.20	× 10	=	82.00
On 40 mesh	28.24	× 20	=	564.80
On 70 mesh	13.48	× 40	=	539.20
On 100 mesh	4.26	× 70	=	298.20
On 140 mesh	3.48	× 100	=	348.00
On 200 mesh	2.74	× 140	=	383.60
On 270 mesh	3.30	× 200	=	660.00
On pan	6.60	× 300	=	1.980.00
	72.38			4,866.20

$$\frac{4,866.20}{72.38} = 67, \text{ the grain fineness.}$$

It is proposed that grain fineness be classified by the following zones:

Grain class	Grain fineness zone	Grain class	Grain fineness zone
No. 1	200 to 300	No. 6	40 to 49
2	140 to 199	7	30 to 39
3	100 to 139	8	20 to 29
4	70 to 99	9	15 to 19
5	50 to 69	10	10 to 14

Therefore sample No. 624, with calculated grain fineness of 67, is in grain class No. 5.

Clay Content

Clay content is classified by the following zone limits in per cents.

Clay class	Clay zone content	Clay class	Clay zone content
A	0.0 to 0.4	F	15.0 to 19.9
B	0.5 to 1.9	G	20.0 to 29.9
C	2.0 to 4.9	H	30.0 to 44.9
D	5.0 to 9.9	I	45.0 to 59.9
E	10.0 to 14.9	J	60.0 to 100.0

Sample No. 624 contains 27.56 per cent clay and therefore is in class G. This sample might then be designated as a No. 5 G sand. Other terms must be used to express the bond strength and permeability.

A table at the end of this report gives the computed grain fineness or grain size for each of the samples. About 40 of the computations were made by A. A. Grubb, chairman of the sub-committee on grading, and the rest by the writer. The principal feature of the table is the classification of each sample according to the scheme given under Standard Tests.

CLASSIFICATION

The method of classifying molding sand commonly adopted by producers is to rub in the hand or between the fingers to determine the fineness grade, and to moisten and squeeze in the hand into a lump or pat and jounce the same on the hand to determine the bond. A more accurate and a practical way of determining the grade size is by passing the sand through a set of sieves and measure the percentage of the sand which is retained on each size of sieve.

In his admirable report on the molding sands of Illinois, Littlefield[1] proposed a classification based on maximum size grade percentage and color. The writer does not wish to propose any classification or name any types. I have found however by plotting the screen tests in the same manner as illustrated by Littlefield, that the

[1]Littlefield, M. S., Natural-bonded molding and resources of Illinois: Illinois Geological Survey, Bull. No. 50, pp. 75-86, 1925.

samples collected in Pennsylvania are readily grouped by distinct types. The first three are the same as Littlefield's, so far as screen test goes.

I. Maximum size grade percentage, excepting the clay grade, on or above 100-mesh; with the silt (—270 mesh) grade percentage less than one-half that of the clay.

II. Maximum size grade percentage, excepting the silt (—270 mesh) and clay, on 140-mesh or below.

III. Maximum size grade percentage, excepting the silt (—270 mesh) and clay grades, on or above 100-mesh; with a silt percentage more than half the clay percentage.

IV. Size grade percentage increasing almost regularly with decrease in size of mesh.

V. Maximum size grade percentage on or above 70-mesh and percentages of all sizes smaller than 140-mesh negligible.

Type I includes some unwashed silica sand with natural bond, and river terrace or flood plain deposits.

Type II includes Susquehanna and Delaware River old flood plain deposits and glacial pond deposits.

Type III includes river flood plain, river terrace, abandoned river channel, Susquehanna and Delaware River old flood plain, and glacial lake deposits. Also some silica sands.

Type IV includes old flood plain, surface wash, and high terrace deposits.

Type V includes washed silica sands produced by crushing and grinding hard rock.

From the above it would seem that classification of natural-bonded molding sands by origin or geologic occurrence is of no practical or commercial interest. Classification by fineness has long been common practice and these screen analyses are only an extension of the old method of grading sands. Grain size alone, however, is not enough for a basis on which to buy or sell molding sand. The bond strength and permeability of a sand are equally to be considered.

Therefore the accompanying figures graphically representing the grain size of some of the molding sands produced in Pennsylvania are not meant to establish types for commercial specifications, but merely to show the similarity and differences of grain size percentage in certain sands.

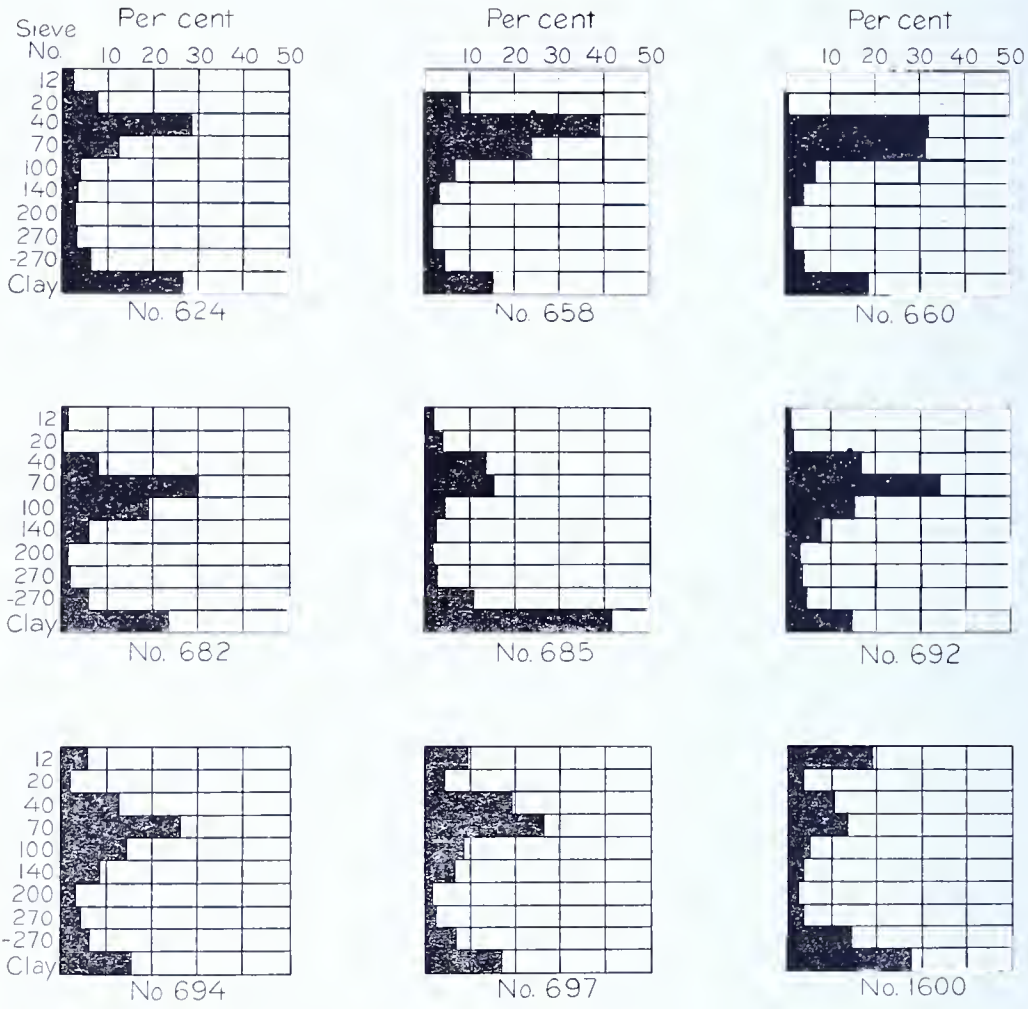

Fig. 1. Grain-size graphs of Type I sands.

No. 624. F. B. Frock, McSherrytown, Adams County.
No. 658. Eastern Clay Products Co., Inc., Hutchins, McKean County.
No. 660. Eastern Clay Products Co., Inc., Hutchins, McKean County.
No. 682. W. M. Cronister, Mines, Blair County.
No. 685. West Penn Sand Co., Blairsville Intersection, Westmoreland County.
No. 692. A. C. Edwards, Broad Ford, Fayette County.
No. 694. A. C. Edwards, Connellsville, Fayette County.
No. 697. Gratztown Sand Co., Gratztown, Westmoreland County.
No. 1600. James Jiles Company, Pittsburgh, Allegheny County.

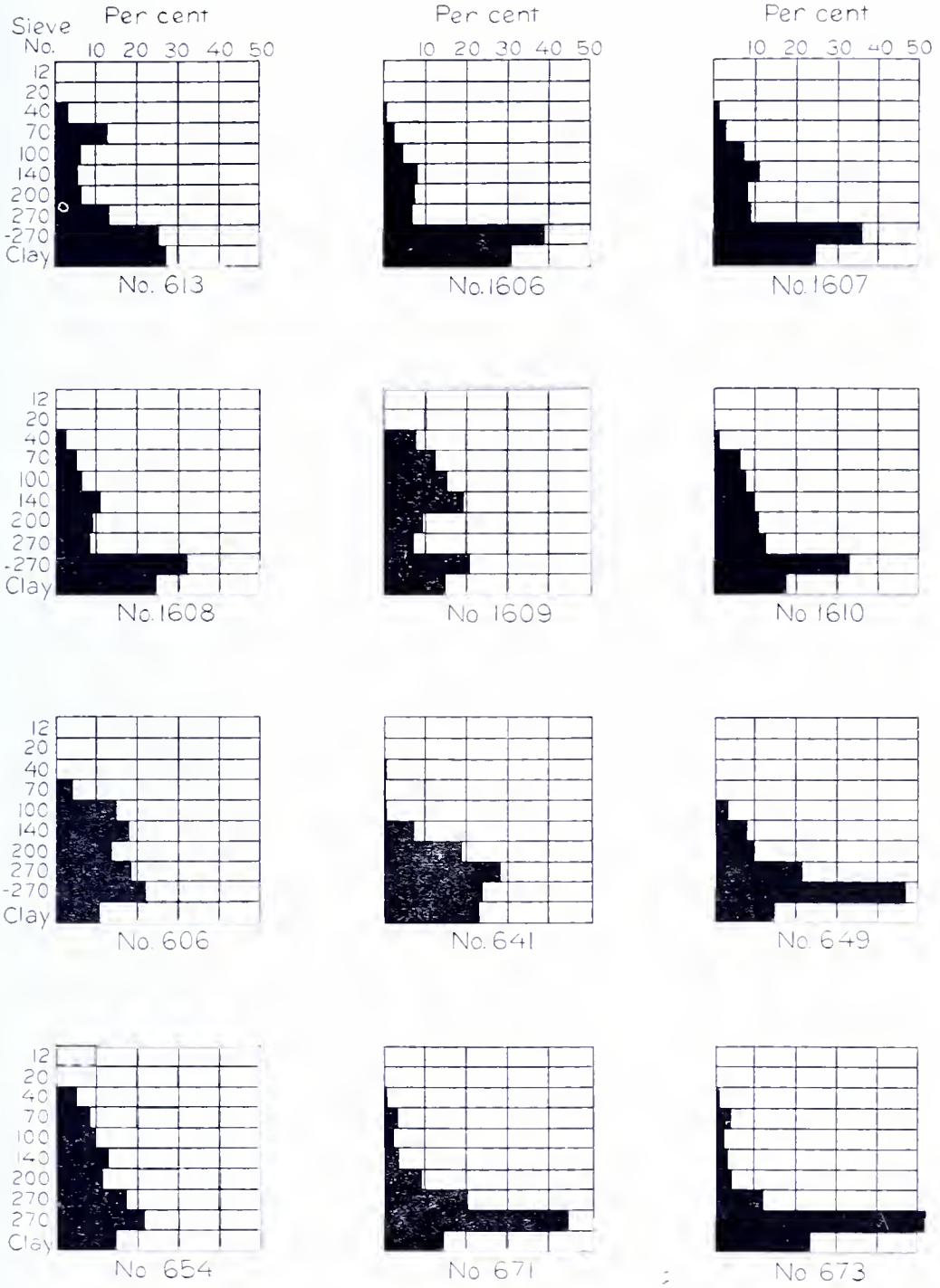

Fig. 2. Grain-size graphs of Type II sands.

No. 613. Geo. F. Pettinos, Tullytown, Bucks County.
No. 1606. J. W. Paxson Co., Tullytown, Bucks County.
No. 1607. J. W. Paxson Co., Tullytown, Bucks County.
No. 1608. J. W. Paxson Co., Tullytown, Bucks County.
No. 1609. J. W. Paxson Co., Tullytown, Bucks County.
No. 1610. Brennan Sand Co., Tullytown, Bucks County.

No. 606. P. L. Rex, Slatedale, Lehigh County.
No. 641. Walker Sand Co., West Springfield, Erie County.
No. 649. Superior Sand Co., Atlantic, Crawford County.
No. 654. Geo. A. Ready, Oil City, Venango County.
No. 671. Marietta Sand Co., Marietta, Lancaster County.
No. 673. E. E. Fleurie, New Market, York County.

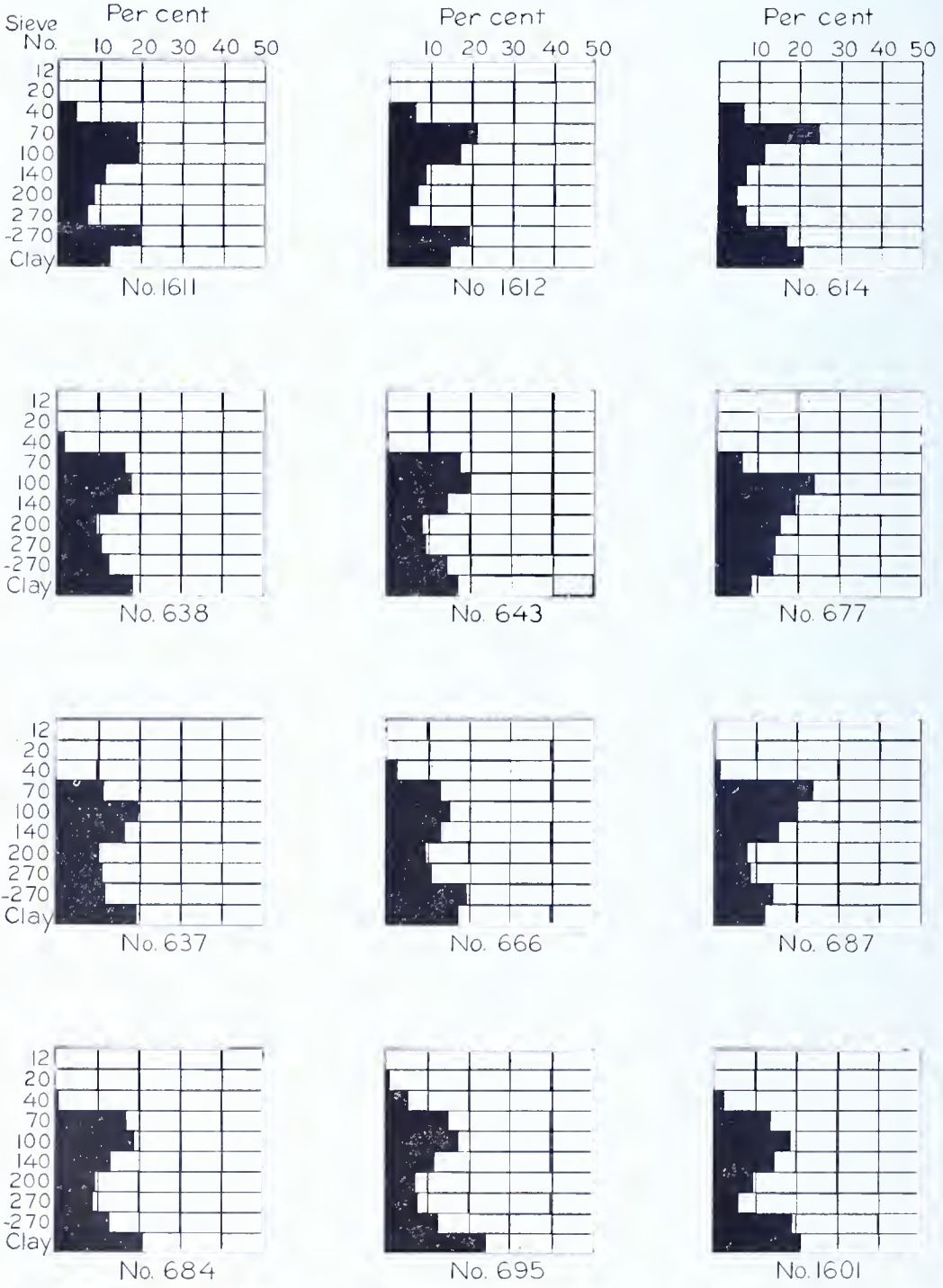

Fig. 3. Grain size graphs of Type III sands.

No. 1611. Brennan Sand Co., Tullytown, Bucks County.
No. 1612. Brennan Sand Co., Tullytown, Bucks County.
No. 614. Geo. F. Pettinos, Tullytown, Bucks County.
No. 638. Gardner Sand Co., Ridgway, Elk County.
No. 643. Gardner Sand Co., Ridgway, Elk County.
No. 677. Samuel C. Loreman, Roaring Creek, Montour County.
No. 637. Oscar Heath, Emporium Junction, Cameron County.
No. 666. W. W. Gulick, Riverside, Northumberland County.
No. 687. Hoey & Gallaher, Kittanning, Armstrong County.
No. 684. C. L. Tittle, Cokeville, Westmoreland County.
No. 695. J. K. McIntire, Perryopolis, Fayette County.
No. 1601. Lorain Steel Co., Johnstown, Cambria County.

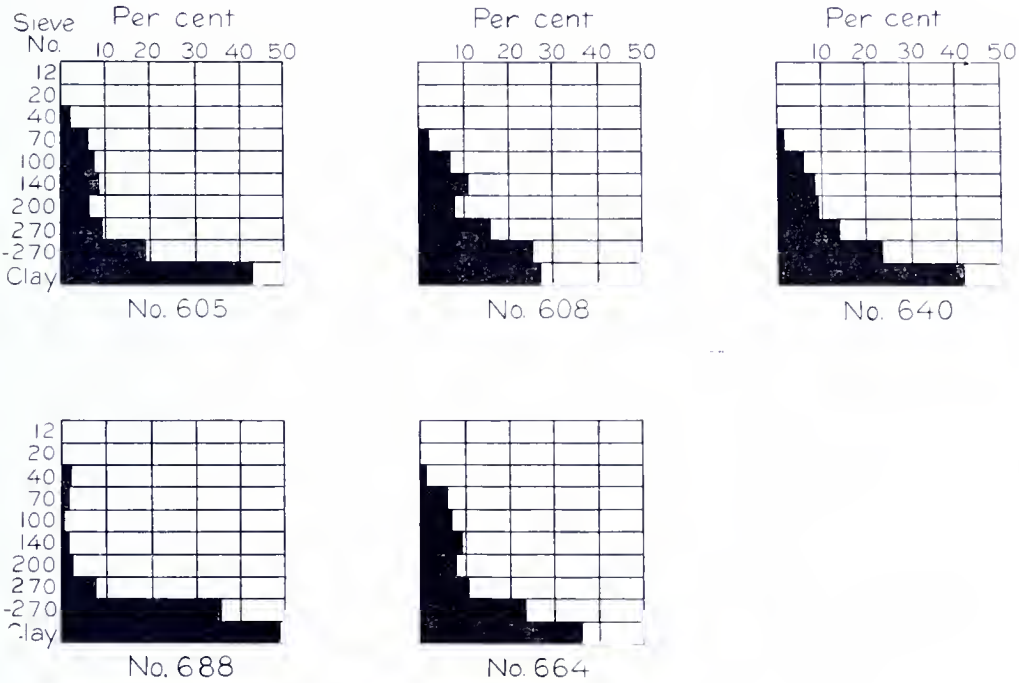

Fig. 4. Grain-size graphs of Type IV sands.

No. 605. Schuylkill Valley Sand Co., Berne, Berks County.
No. 608. C. O. Hunsicker, Emaus, Lehigh County.
No. 640. Gardner Sand Co., Ridgway, Elk County.
No. 688. Undeveloped, Freeport, Armstrong County.
No. 664. S. H. Croan, Dover, York County.

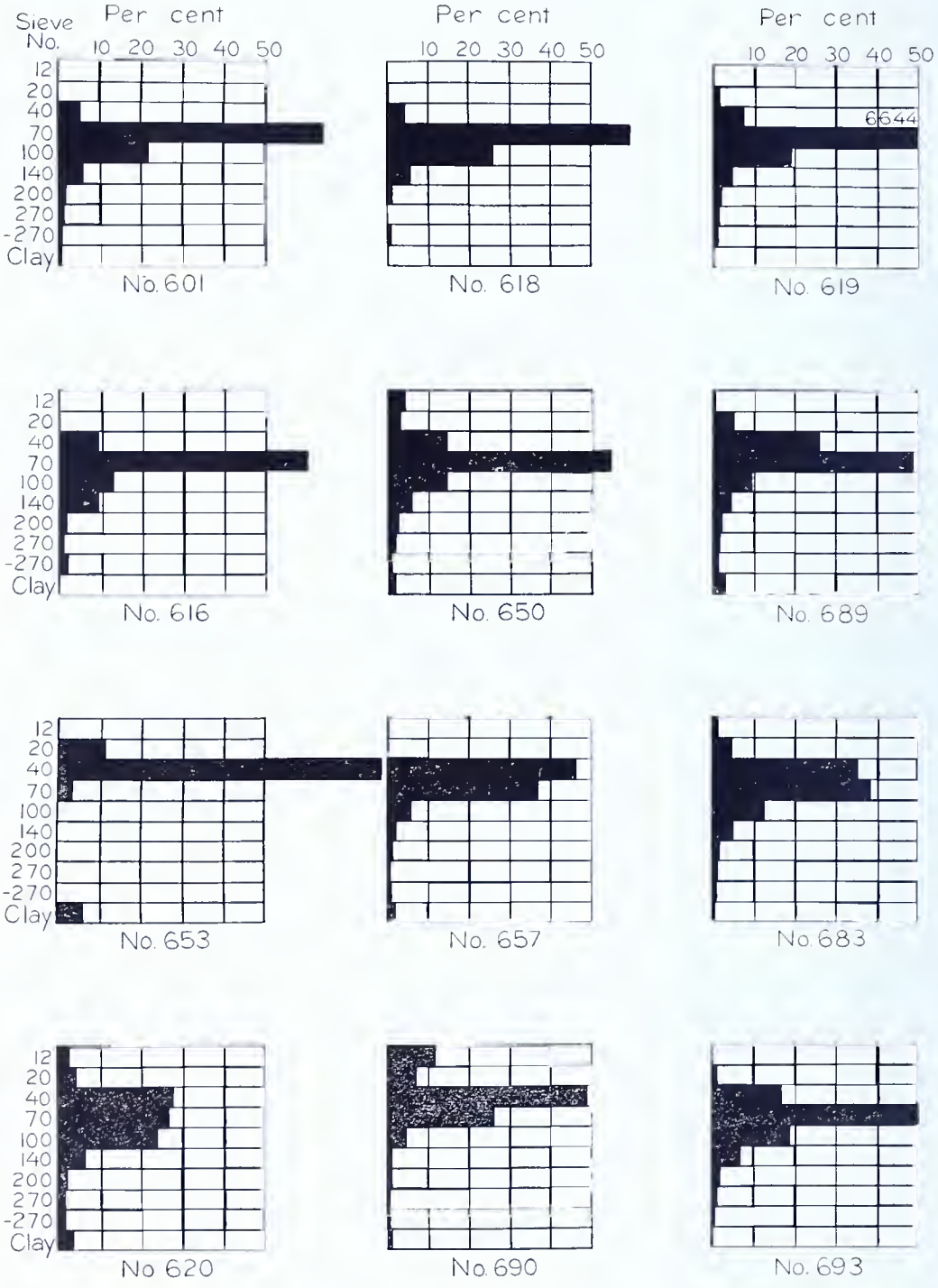

Fig. 5. Grain-size graphs of Type V sands (silica).

No. 601. J. H. Miller, Burnham, Mifflin County.
No. 618. Richland Sand Products Co., Emlenton, Venango County.
No. 619. Richland Sand Products Co., Emlenton, Venango County.
No. 616. Winfield Sand Co., West Winfield, Butler County.
No. 650. Greenville Silica Products Co., Greenville, Mercer County.
No. 689. Hunkers Sand & Stone Co., Hunkers, Westmoreland County.

No. 653. Dick Sand Co., Polk, Venango County.
No. 657. Falls Creek Sand & Stone Co., Falls Creek, Jefferson County.
No. 683. Derry Glass Sand Co., Derry, Westmoreland County.
No. 620. E. T. Millard Sand Works, Shippensburg, Franklin County.
No. 690. J. K. Davison Co., Pittsburgh, Allegheny County.
No. 693. Dunbar Corporation, Dunbar, Fayette County.

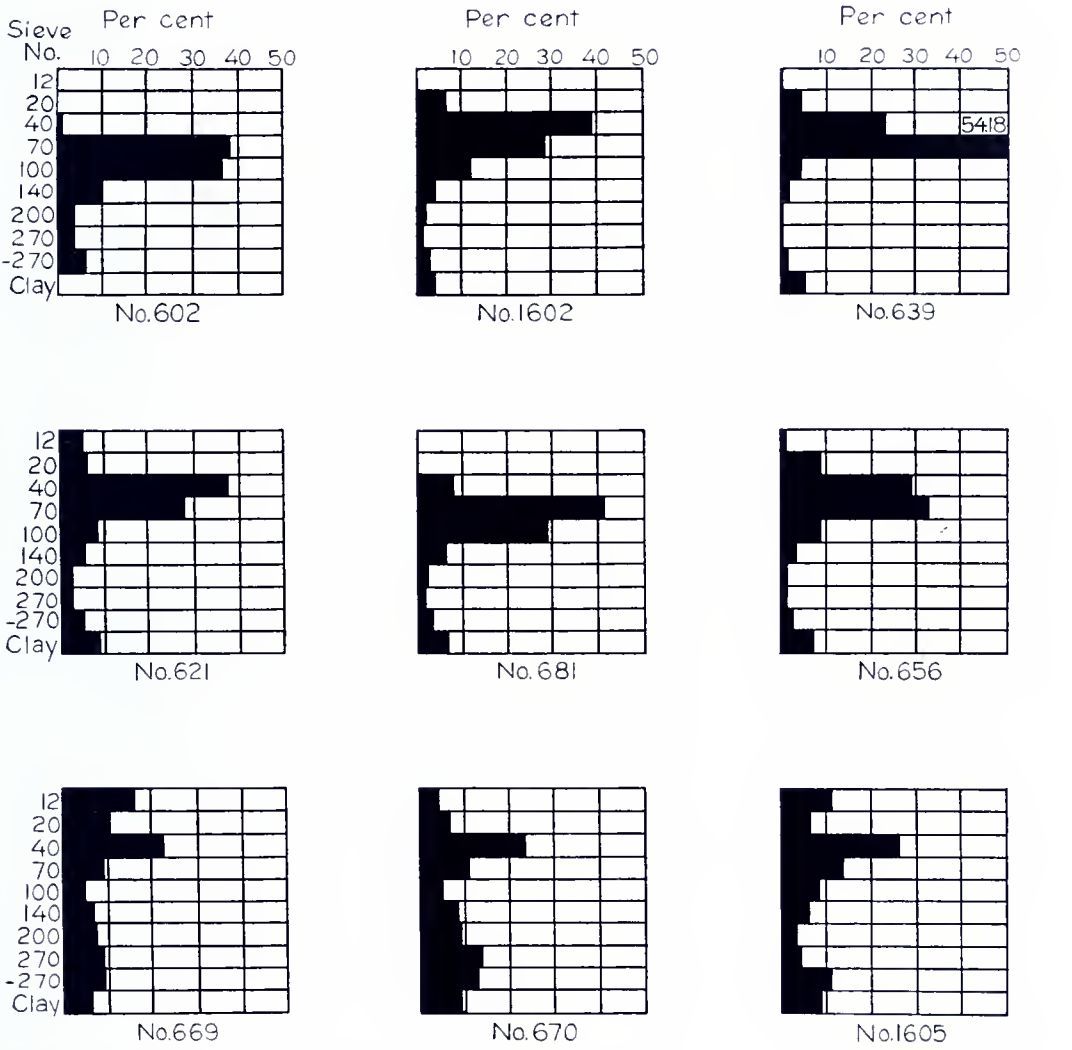

Fig. 6. Grain-size graphs of silica sands.

No. 602. Lycoming Silica Sand Co., Montoursville, Lycoming County.
No. 1602. Keystone Sand Products Co., Jonestown, Lebanon County.
No. 639. Gardner Sand Co., Ridgway, Elk County.
No. 621. Mt. Cydonia Sand Co., Pond Bank, Franklin County.
No. 681. W. M. Cronister, Mines, Blair County.
No. 656. Falls Creek Sand & Stone Co., Falls Creek, Jefferson County.
No. 669. A. C. Bowers & Sons, Rohrerstown, Lancaster County.
No. 670. A. C. Bowers & Sons, Rohrerstown, Lancaster County.
No. 1605. Valley Forge Sand Co., Valley Forge, Chester County.

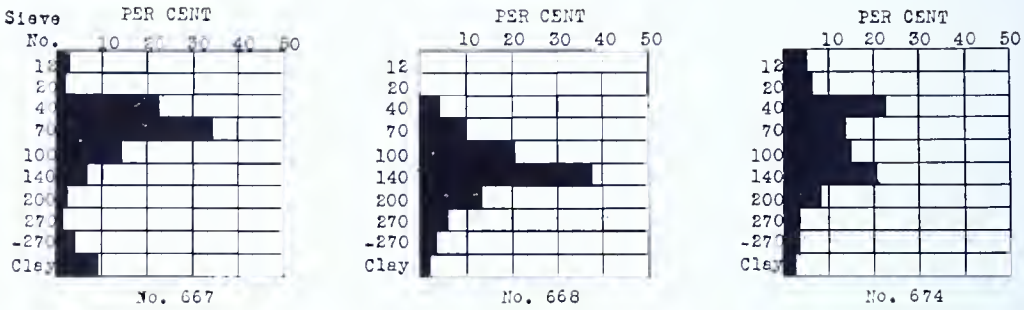

Fig. 7. Grain-size graphs of silica sands from Mt. Holly Springs.

No. 667. Silica Sand Co., Mt. Holly Springs, Cumberland County.
No. 668. Silica Sand Co., Mt. Holly Springs, Cumberland County.
No. 674. J. E. Peterson, Mt. Holly Springs, Cumberland County.

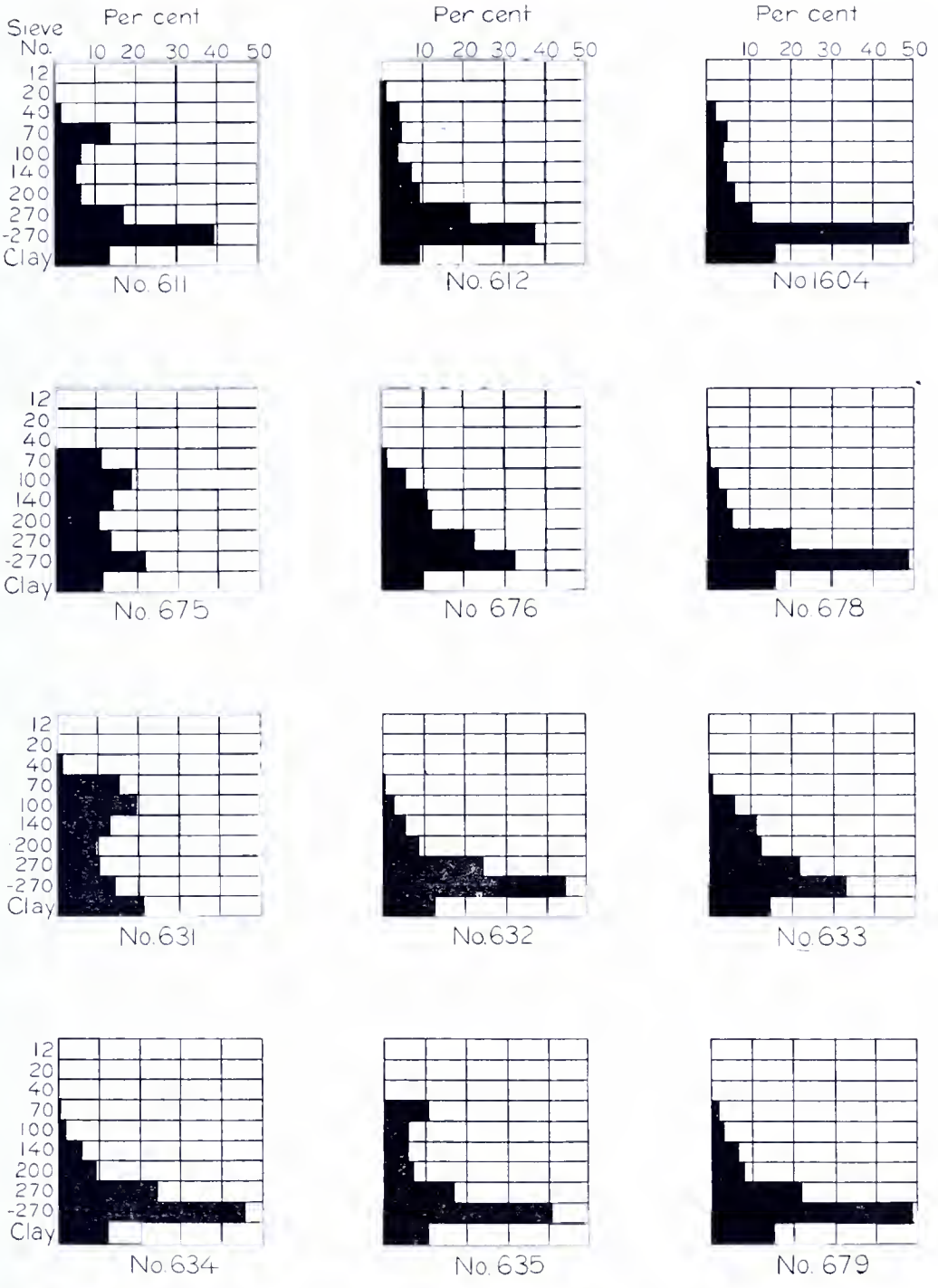

Fig. 8. Grain-size graphs of Catawissa and Danville sands.

No. 611. Geo. F. Pettinos, Catawissa, Columbia County.
No. 612. Geo. F. Pettinos, Catawissa, Columbia County.
No. 1604. Geo. F. Pettinos, Catawissa, Columbia County.
No. 675. Chas. Pettinos, Catawissa, Columbia County.
No. 676. Samuel C. Loreman, Roaring Creek, Montour County.
No. 678. Samuel C. Loreman, Roaring Creek, Montour County.

No. 631. W. W. Gulick, Riverside, Northumberland County.
No. 632. W. W. Gulick, Riverside, Northumberland County.
No. 633. W. W. Gulick, Riverside, Northumberland County.
No. 634. W. W. Gulick, Danville, Montour County.
No. 635. W. W. Gulick, Catawissa, Columbia County.
No. 679. Danville Stove & Mfg. Co., Danville, Montour County.

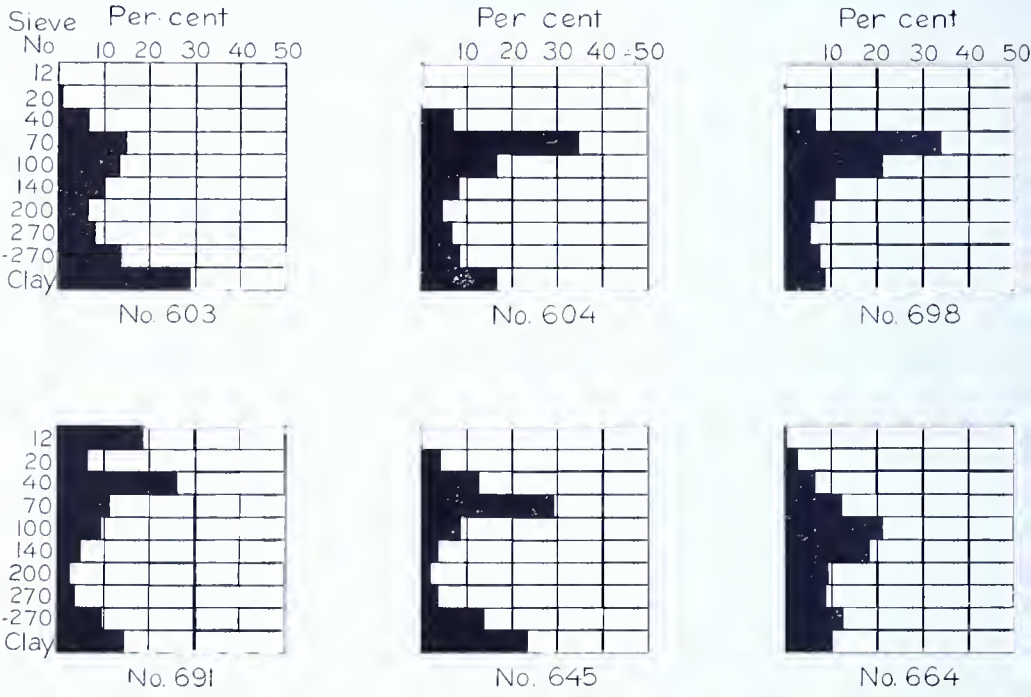

Fig. 9. Grain-size graphs of miscellaneous sands.

No. 603. C. S. Saylor, Hamburg, Berks County.
No. 604. C. S. Saylor, Hamburg, Berks County.
No. 698. Ed. Bollinger, Walts Mill, Westmoreland County.
No. 691. Gratztown Sand Co., Gratztown, Westmoreland County.
No. 645. Walker Sand Co., Springfield, Erie County.
No. 644. Walker Sand Co., Springfield, Erie County.

From a study of these screen tests, together with the data on bond strength and permeability, all of which are given in the tables at the end of this report, the foundryman may be able to familiarize himself with the characteristics of the type of molding sand he is using, and perhaps, by comparison of tests, to find a new and nearer source of sand suitable for his foundry. In view of the fact that some central Pennsylvania foundries have used Pennsylvania molding sand with satisfaction for many years for casting general gray iron custom work, including machinery, street grates, manholes, etc., and other central Pennsylvania foundries are using sand from the Albany

district, New York, for the same kind of castings, it would seem that a study of these tests, and a comparison with tests of competing sands from other States published by the American Foundrymen's Association[1] would be of much benefit. I do not know of any deposits in Pennsylvania like the strongly bonded molding gravel from Millville, New Jersey, or like the Lumberton loam, but I do believe that the purchase of much of the Albany sand used in this State is unnecessary, and that silica, fire, or core sand produced in western and central Pennsylvania should serve the need of a Westmoreland County foundry just as well as dune sand from Michigan City, Indiana. Pennsylvania sand may cost several times as much per ton, but the lower freight charge should counterbalance the greater cost.

PRODUCING AND MARKETING

As natural bonded molding sand deposits are shallow, have little overburden, and are unconsolidated, the method of digging is simple. The deposits are practically flat-lying and are covered usually with less than one foot of soil. In most cases the land has been cultivated and is free from brush or trees. As only a few square yards of sand are uncovered at a time and the top surface must be cleaned by hand, it is customary to remove the soil with a hand shovel. With only one or two exceptions the molding sand is then dug by hand and loaded in wagons for delivery to the foundry or to a railroad car. Customarily the sand is removed from a narrow strip, and the soil taken from the next strip is spread over that from which the sand has been removed. The result is that when the molding sand has been taken from a field, the soil is back in place and ready to cultivate again, but the field is lower by the thickness of sand removed. Most of the bonded molding sand deposits now being worked in Pennsylvania are underlain by or grade into sharp sand and watchfulness on the part of an experienced man is required to see that only the bonded sand is dug, or in some places, that the needed quantity of sharp sand is included to give the desired permeability or openness. Some deposits are thick enough to dig with a small power shovel but the quantity produced does not justify the cost of this method of digging.

At only one place has the writer seen molding sand dug by machine. This is in the Brennan Sand Company's operation about 2½ miles east of Tullytown. Here after stripping one foot of soil a bed of molding sand 3 to 6 feet thick is uncovered. The upper two feet is homogenous and a solid color; the lower part mottled gray and brown. All is used. The digging machine consists of caterpillar tread on which are mounted a digger, a bucket belt elevator, and a

[1]Report of Joint Committee on Molding Sand Research: Trans. Am. Foundrymen's Assn., vol. 32, pt. 2, pp. 222-391, 1925.

small gasoline motor. The digger is a horizontal bar with steel blades or bars so mounted that when pushed against the sand bank and revolved, they cut down the sand and move it from the ends toward the middle where it is picked up by the string of buckets. These deliver the sand to a chute which spills directly into the box of a small automobile truck. As digging advances into the base of the deposit the upper part caves or is pushed down.

The molding sand is mixed naturally in the field in the process of loading in wagons, unloading into cars, and spreading or leveling in the cars.

The unbonded silica sand is produced, in all cases, by quarrying a sandstone, and reducing the rock to sand by crushing and grinding. In most cases the sand is washed before being shipped.

ORIGIN AND GEOLOGY OF MOLDING SAND

DEFINITION

Molding sand, according to the Century dictionary, is a mixture of sand and loam of which molds for use in a foundry are made. A recent definition is as follows[1]: "Molding sand may be defined as any material which, when moist, can be formed into a mold from which usuable metal castings can be made. This includes both artificially bonded molding sands, which are artificial mixtures of sand and clay, and natural bonded molding sands, which are mixtures of sand and clay as they occur in nature."

A more liberal definition seems necessary to cover the subject. "Molding sands are siliceous sandy materials used in foundries for making molds and cores for casting metal. They vary from loamy clay to clean silica sand or gravel, the character of the material used depending on the kind of metal to be poured, the size of the casting, the surface desired, and the place in the mold where the sand is to be used. Molding sands should be high in silica to be sufficiently refractory, should have a strong bond when moist, and should have less then 1 per cent of iron oxide. Some molding sands lack bond and are tempered by the addition of a small amount of clay or other binding material.[2]" "Other binding material" includes clay, molasses water, flour, etc., used as binder in core sand. Some foundries are using clay instead of fresh sand to renew the bond in burned sand.

Molding sands are naturally divided into two classes, those that have natural bond, and those to which bond must be added. The natural-bonded sands are used for molding iron, brass, bronze, and aluminum, and the unbonded or silica sand for molding steel.

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[1]Littlefield, M. S., Natural-bonded molding sand resources of Illinois: Illinois Geol. Survey Bu'l. No. 50, p. 54, 1925.

[2]Stone, R. W., The production of sand and gravel in 1912; U. S. Geol. Survey Mineral Resources, 1912, p. 631, 1913.

The natural-bonded sands in Pennsylvania with few exceptions are unconsolidated stream and lake deposits of glacial or recent age, and the unbonded sands are made by crushing sandstone.

ORIGIN

It is not within the scope of this report to explain in detail the geologic process by which these deposits were formed. The reader doubtless knows that all sand is derived from pre-existing rock. Two processes tend to disrupt rocks, one chemical, the other mechanical. In the chemical process the least stable minerals in the rocks are decomposed, the dissolved part being carried away by water, and the insoluble residue left in the form of clay. The stable minerals remain then as sand in a clay matrix or with clay in the interstices.

In the mechanical process, perhaps the most important agency is change in temperature, which disrupts rock by causing alternate contraction and expansion in the rock itself. As each different mineral has a different reaction to change in temperature, the grains are gradually loosened. Likewise change in temperature causes expansion and contraction of the water in the pores and ice in the cracks of the rock and so breaks rock down to sand.

When once the individual grains of rock are loosened, they are ready to be moved by water, wind, and gravity. In Pennsylvania transportation by water has been the principal agent active in concentrating sand. Glaciation brought large quantities of rock material into the northern part of the State from New York and Canada, and also produced much sand within the State by the movement of the great body of ice over the surface and by the grinding of rock debris transported by the ice.

After being transported a long or short distance, sand comes to rest or is deposited. Deposition directly from glacial ice results in an unsorted mixture of sand, clay, gravel, and boulders. Molding sand therefore should not be found in glacial moraines.

Running water gathers the sand produced by rock disintegration, transports, and sorts it, the heavy material being rolled along the bed of the stream and the lightest material carried in suspension. This material comes to rest or is deposited where and when the velocity of the stream decreases; the gravel and coarse sand is dropped first, and the finest material last in almost still water. Thus the transported material is sorted. As a general rule the coarsest or heaviest material is deposited farther up stream and in or nearer the channel than the fine material. Uniform thickness and extent of a deposit, and uniformity of grain size therefore will be least expected along a small stream, and most probably along a large river or lake.

When originally deposited a body of sand may have no bonding quality. The present flood plains of our streams furnish some sand

that is used for molding but it is believed that the sands with the best natural bond are those which are found on river terraces which represent old flood plains long abandoned by reason of the river deepening its channel, and those which were deposited in a lake or pond that disappeared thousands of years ago. The reason for supposing these sands have more natural bond is that, after deposition and eventual recession of the water in which they were laid down, the chemical process of disruption begins again, the least stable minerals are decomposed and the insoluble residue is left between the insoluble grains. In the course of a few thousand years a sand originally unbonded may become bonded and suitable for molding sand.

The writer observed in several pits where molding sand was being dug that below a bonded sand of uniform color was a band of mottled sand. This mottling or patchy distribution of color seemed to be also in sand of uniform grain, and is believed by the writer to represent incomplete dissolution of the chemically unstable minerals.

OCCURRENCE

The molding sands collected by the writer include those used for iron and steel, and for cores, and include fine bonded sand, loam, fine gravel, and disintegrated igneous rock. One sample of gravel used for cores came from a glacial lake bottom at a point where a creek discharged into the former lake; another was dredged from the bottom of a river. These and the disintegrated gneiss might be considered outside the province of this report and need not be discussed. A considerable number of the samples are steel molding sands, very refractory and without bond, and were in all cases produced by crushing and washing a highly siliceous sandstone. Five samples used by iron foundries are crushed sandstone which had enough decomposed feldspar to give the sand a natural bond.

Of the natural-bonded iron molding sands, some come from the flood plains of rivers and small streams, some from terraces and abandoned channels above the reach of present floods, some from valleys which held ponds during the glacial period and in which fine sediment was deposited to a depth of several feet, and some from the floor of an ancient glacial lake.

The geologic formations now utilized for steel molding sand are Cambrian quartzites in the southeastern part of the State, the Oriskany sandstone of Devonian age, and several sandstones of the Carboniferous or Coal Measures.

Natural-bonded molding sands. It is impracticable to try to make a map showing the distribution of the natural-bonded molding sands. The flood plain and terrace deposits of the larger streams may contain molding sand, but their occurrence is irregular, determined only

by prospecting, and is as yet unknown except in a few localities. The sediments formed in glacial lakes and ponds and on the flood plains of ancient streams that long since abandoned their channels, are in some places good molding sand, but like the younger terrace and flood plain deposits, their character may change in a short distance horizontally as well as vertically.

From the variety of materials that are dug and used as natural-bonded molding sand, and from the variety of physiographic and geologic relations in which they occur, one might assert that molding sand is where you find it, meaning that no definite rule can be laid down as to where it may be found. It must be borne in mind that what is good sand for one molder is worthless for another; even hill wash may be suited to some jobs, and much sand that the foundryman who could use it would call molding sand is used for fills because its suitability for molding is not recognized, or there is no local market.

For further knowledge of Pennsylvania's natural-bonded molding sands, extensive prospecting must be done. They may be found in a wide range of topographic positions although the flood plain, terraces and abandoned channels of present or ancient streams and floors of abandoned lakes are the most likely places.

Silica sand. The hard rock formations that are suitable to crush for silica sand are very abundant throughout most of the State. In the eastern and central parts of the State these formations commonly dip at high angles and outcrop in long narrow bands. Because of their insolubility and resistance to weathering they form ridges.

As the Cambrian (Chickies) quartzite and Devonian (Oriskany) sandstone are ground to silica sand and used by certain foundries it is reasonable to assume that the Tuscarora quartzite of Silurian age, and the more siliceous of the Carboniferous sandstones may be suitable for this purpose. The quantity of this material is inexhaustible. For hundreds of miles each of these formations is exposed, the places where they may be quarried advantageously are numerous, and the thickness is considerable. The Tuscarora formation, for example, ranges from 200 to 500 feet thick, and outcrops from Delaware Water Gap to Fulton County, thence zigzags across the State to Williamsport, and from there past Lock Haven and Tyrone to the Maryland line south of Bedford. The Oriskany has much the same distribution as the Tuscarora.

The Chickies formation is confined to southeastern Pennsylvania and is most extensive in Berks and Chester counties. It has long been quarried on the big ledge on Susquehanna River just above Columbia, and in the South Mountains between Harrisburg and Waynesboro.

The sandstones of Carboniferous age are mostly west of the Allegheny Front and in the northern counties. The Pocono sandstone

at the base, the Pottsville formation, composed of the Sharon, Connoquenessing, and Homewood sandstones, and numerous other sandstones of the Coal Measures are widely distributed all over the western part of the State.

LOCATION AND DESCRIPTION OF SAMPLES TESTED

ADAMS COUNTY

McSherrytown. So far as known to the writer the only sand produced in Adams County for use in foundries is that dug at McSherrytown by F. G. Frock. The pit is in a road corner on the main route from Hanover to Gettysburg. A siliceous limestone was quarried here for many years for crushed stone, beginning about 20 years ago, but lately Mr. Frock has been digging only the sand and clay resulting from weathering of the limestone. He can produce building sand, molders clay, and core sand, the last being a mixture of the clay and sharp sand. The material is dug and screened by hand and elevated to a bin. The core sand produced here is used by foundries in Hanover, McSherrytown, and Waynesboro. Sample No. 624 was taken from the core sand bin of the Landis Machinery Company at Waynesboro.

ALLEGHENY COUNTY

Pittsburgh. J. K. Davison Company of Pittsburgh, dredges sand from the rivers in that vicinity for various purposes. Some of this washed river sand is used by iron foundries for cores. Sample No. 690, taken by the writer from the stock bin of a foundry at Greensburg, represents this core sand.

The James Jiles Company, Stayton and Highwood Streets, North Side, Pittsburgh, is digging sand and gravel from a deposit more than 100 feet above the level of the river. The deposit is loamy at the top and gets sharp with depth. Sands of different character in the pit face are all mixed in a dry pan grinder. The product is a coarse, strongly bonded sand with small pebbles used for dry sand casting. Sample No. 1600 is the Jiles sand from the stock bin of a foundry at Latrobe.

ARMSTRONG COUNTY

Freeport. At the cemetery on the hill between Freeport and Dock Hollow the writer observed a deposit of sand in the road cut and took a sample (No. 688) by cutting a vertical trench in the part of the section that seemed suitable for molding sand. This deposit is 250 feet above Allegheny River at the same general level as terraces are found elsewhere in this vicinity along the Allegheny and Kiskiminitas Rivers and Buffalo Creek. The deposit is not utilized near the

cemetery but if the sand sampled is suitable for iron molding, it is probable that similar deposits can be found elsewhere on the high terraces along these streams in a position better situated for development.

The section exposed at the cemetery is, soil and sand, 3 feet; molding sand (sampled), 2 feet; sharp sand. Several acres here probably are underlain by this deposit.

Kittanning. Hoey & Gallaher, foundry men, at Kittanning, are using a molding sand which they dig from a little knoll on the flood plain on the west bank of Allegheny River about 3 miles north of the city. Under about 6 inches of soil they find 3 feet of molding sand, underlain by sharp sand. They use this molding sand for casting car wheels and general custom work. The sample (No. 687) was taken by the writer from the stock bin at the foundry.

BERKS COUNTY

Hamburg. On the west bank of Schuylkill River, just above the covered bridge and only two blocks from the Pennsylvania Railroad and the Philadelphia & Reading Railroad, molding sand has been dug from about an acre. This is on the flood plain of the river and about one foot of gray sharp sand mixed with coal covers the molding sand which is a deposit 1 to 2 feet thick and of alluvial origin. The molding sand is distinctly reddish and is so tough that a pick makes a slick mark in it. This is underlain by a gray sharp sand with much less bond. The deposit was not being worked when visited in July 1923; the appearance of the field suggested intermittent operation and irregularity in the deposit. Similar sand should be found elsewhere on the river flood plain. According to C. S. Saylor, of the P. & R. R R, real estate department, this reddish molding sand is used for heavy iron castings in Reading, Kutztown, Birdsboro, Tamaqua, etc. A sample (No. 603) of the reddish sand was dug by the writer from the face of several small pits within a few rods of each other. From the same pits sample No. 604 was taken to represent the lightly bonded sand underlying the reddish sand represented by sample No. 603. As inquiry failed to get the information, the writer does not know if this lower sand is used by foundries.

Berne. On the east bank of Schuylkill River opposite Berne station on the P. & R. Railroad and nearly ½ mile below Five Locks on the Schuylkill canal is a molding sand pit operated by the Schuylkill Valley Sand Company, Berne. The pit is alongside the Pennsylvania Railroad and 2 ½ miles south of Hamburg. It is in the flood plain only a few feet above the river and presumably the sand is part of an alluvial deposit underlying many acres up and down the river.

The pit had been worked during the summer but no one was on the property when visited by the writer in July 1923. About one foot of soil is removed and nearly 5 feet of sand taken along a straight cut parallel to the river. An occasional bowlder is found in the sand. Sample No. 605 representing the full thickness of the deposit was taken in two places in the working face. The sand is shipped to nearby iron foundries.

BLAIR COUNTY

Mines. Five miles southwest of Williamsburg at Oreminea (Mines P. O.), the end of the Springfield Branch of the Pennsylvania Railroad, a silica sand was produced for many years by the Cronister Sand & Supply Company of Altoona. When visited in company with W. M. Cronister, 2520 Beale Avenue, Altoona, August 6, 1925 the plant had been idle for two years and the property was for sale. It consists of 35 acres on the crest of a ridge about 1,100 feet above sea level containing a deposit of silica sand, possibly disintegrated Medina sandstone, and a plant for preparing the sand for market. The face of the pit, all in silica sand, is about 35 feet high, and Mr. Cronister says that a test hole showed 30 feet of white sand below the bottom of the pit. The overburden of loam and hill wash is 3 to 4 feet deep. Under it is brown sand but the larger part of the deposit and lying below the brown sand is white. Sample No. 681, dug by the owner and the writer represents the white sand which was used by the Cambria Steel Company for fire sand. Sample No. 682 is the brown silica sand from the upper part of the pit that was used by the Pennsylvania Railroad for cores.

Quarry cars, loaded by hand, were hauled from the pit up into the plant by cable and dumped on a bar grizzly with 2-inch openings. The sand passing the grizzly was ground in a 7-foot dry pan and the oversize went to a 10-ton Acme jaw crusher. The sand went from the pan by elevator to a chute which spilled directly into a freight car. The plant has its own steam power and is served by a 500-foot private siding.

BUCKS COUNTY

Tullytown. On the Frank Briggs farm about ½ mile northeast of Tullytown, J. W. Paxson Company, Philadelphia, digs several grades of molding sand. This farm adjoins the Pennsylvania Railroad and is close to the Delaware Canal. The pits are 1 mile from Delaware River, less than 20 feet above sea level, and in the Cape May formation which is of fluvial origin in late glacial time. This formation underlies many square miles on both sides of Delaware River but only in limited areas has molding sand been found in it. In these small areas the fineness of the sand may vary within a few rods enough to

place it in a different grade. This farm is said to have 30 acres of molding sand.

At all of the pits on the Briggs farm, one foot of soil is stripped, as required by the Japanese beetle quarantine, and about 3 feet of molding sand is dug. The lower part of the section may be gray and sharper than the upper part. Samples 1606-9 were cut and bagged by Herbert H. Chilton, the local representative of J. W. Paxson Company, October 1, 1925.

Sample No. 1606. J. W. Paxson Co., Tullytown, grade 00
Sample No. 1607. J. W. Paxson Co., Tullytown, grade 0
Sample No. 1608. J. W. Paxson Co., Tullytown, grade 1
Sample No. 1609. J. W. Paxson Co., Tullytown, grade 1 open

Grade 00 (Sample No. 1606) is used for stove plate work and other fine castings. The coarser grades are used for general custom work, machinery, etc., and extensively for radiators.

The Brennan Sand Company, Tullytown, digs molding sand 2 ½ miles east of Tullytown and ¼ mile north of Delaware River on the Herbert Fish farm. This deposit likewise is in the Cape May formation and less than 20 feet above sea level. The pits adjoin the huge gravel stock piles of the Van Sciver Corporation and are in a level field less than a mile from the Manor sand and gravel plant of Chas. Warner Company. One foot of soil is stripped on account of the Japanese beetle quarantine and 3 to 6 feet of sand is dug. The first two feet of sand below the soil is a solid color and without apparent bedding. The lower part of the deposit is mottled gray and brown. Perhaps an acre or two has been worked out. Three samples were dug from the face in different parts of the pit by T. J. Brennan in the writer's presence October 1, 1925.

Sample No. 1610. Brennan Sand Co., Tullytown, grade No. 0 for brass and ornamental iron, from a 6 foot face.

Sample No. 1611. Brennan Sand Co., Tullytown, grade No. 1, widely used for radiators and other medium weight casting in eastern Pennsylvania, New Jersey, Maryland, and Delaware. Pit face about 4 ½ feet.

Sample No. 1612. Brennan Sand Co., Tullytown, grade No. 2, used for radiators and heavy castings. Pit face about 3 feet.

This pit is the only one in the State at which the writer saw bonded molding sand dug by machinery. Plate XII. A small gasoline engine mounted on a caterpillar tread drives a digger consisting of blades on a horizontal axis. The flare of the blades on one end of the axis is opposite to that on the other end so that the sand as dug is moved to the middle of the digger where it is raised by a bucket belt elevator and spilled over a chute to the box of a truck. The trucks used are one ton automobiles. These haul the sand to a platform alongside a railroad spur where they dump direct into cars.

Plate XII. Digging molding sand by machine near Tullytown, Bucks County.

Molding sand is dug at Tullytown also by Geo. F. Pettinos, Philadelphia. His pits are on the William Briggs farm, ½ mile from Tullytown and right on the Pennsylvania Railroad. The sand is of the same origin as those mentioned above, is stripped of one foot of soil, dug by hand to a depth of about three feet and used for iron castings the same as other sand of the same grade. The samples were dug under the direction of Mr. Pettinos and shipped by him direct to the laboratory.

Sample No. 613. Geo. F. Pettinos, Tullytown, grade 0.

Sample No. 614. Geo. F. Pettinos, Tullytown, grade 4.

Mr. Pettinos has been digging molding sand also on the Chilton farm ¾ mile west of Tullytown.

BUTLER COUNTY

West Winfield. The only samples obtained in Butler County were silica sand for steel foundries. The Winfield Sand Co., 2215 Oliver Bldg., Pittsburgh, has a large sand mine at West Winfield on the east border of the county and on a branch of the Pennsylvania Railroad. Here the Clarion sandstone, which ranges up to 50 feet thick, is mined by the room and pillar method from a drift reported to be about 2,000 feet long. A stratum about 10 feet thick is mined and timbering is not required. This sugary white rock is crushed in a 26 by 38-inch Traylor bulldog jaw crusher, ground in wet pans, screened, and cleaned in screw washers. Most of the product is sold for grinding plate glass but some is used in steel foundries. The operator forwarded three samples to the laboratory.

Sample No. 615. Winfield Sand Co., West Winfield, coarse grain,
Sample No. 616. Winfield Sand Co., West Winfield, medium grain,
Sample No. 617. Winfield Sand Co., West Winfield, fine grain.

CAMBRIA COUNTY

Johnstown. The Lorain Steel Company at Johnstown sent to the laboratory a sample (No. 1601) of the sand which they dig on their own property for their own use. This is a heavy loam that occurs in the flat along a creek in Ferndale, a suburb of Johnstown. Six to eight inches of soil is removed and 5 to 7 feet of loam taken. It contains no gravel. The loam is dug by hand and hauled by truck to the foundry, where it is used for a great variety of gray iron castings. The deposit is on the B. & O. Railroad.

CAMERON COUNTY

Emporium Junction. In a meadow on the flood plain of Sinnemahoning Creek at Emporium Junction on the Pennsylvania Railroad, Oscar Heath strips 12 to 18 inches of soil and digs 3 to 5 feet of bonded molding sand for use in the local foundries. It probably underlies several acres on this farm. The Emporium Iron Company uses it for runways to a pig-casting machine. It is used by the Emporium Machine Company for casting car wheels, for acid pans up to 4,500 pounds in weight, and for all machinery castings, both green and dry sand. It is reported to be used successfully also for casting aluminum and brass.

Sample No. 636 is the Oscar Heath sand taken by the writer from a stock pile of the Emporium Iron Company, and
Sample No. 637 was dug by the operator for the writer August 11, 1924.

CARBON COUNTY

Lehighton. On the river flat at Lehighton, opposite the Lehigh Valley Railroad Station, molding sand has been dug by Louis Kemp of Allentown since 1914. Several acres of the farm land have been stripped of the molding sand which lies under 6 to 18 inches of soil, and Mr. Kemp estimates that about 16,000 tons remain to be dug. The sand ranges in thickness up to 4 feet (Plate XIII) and is finer grained near the surface than at the bottom. All of the sand is strongly bonded. It contains occasional bowlders up to 2 and 3 feet in diameter. Some of the field near the railroad is all gravel. The sand is loaded by hand into wagons and hauled to the railroad where it is laboriously shoveled into cars. It is used mostly in the Lehigh Valley and in Bangor, Kutztown, and Hazelton for heavy pipe and machinery castings, up to 3½ tons. A sample was taken by the producer and the writer from a loaded car but has not been tested.

Plate XIII. Molding sand pit at Lehighton, Carbon County.

CHESTER COUNTY

Valley Forge. The Chickies quartzite has been quarried for many years at Valley Forge. Silica sand produced here by the Valley Forge Sand Company is made by crushing and grinding this quartzite in a mill on the P. & R. Railroad, across the creek from Washington's headquarters. The stone is quarried on the ridge southwest of the village and brought to the mill on a narrow gnage railroad. When the writer visited the plant in September, 1925, only one grade of silica sand was being made, that represented by sample No. 1605. Preparations were being made to rebuild the mill so as to make smaller grades of sand. This company not only supplies a refractory sand to iron and steel foundries in eastern Pennsylvania, but also has sold its product in Wheeling, West Virginia; Zanesville, Ohio; Indiana Harbor, Indiana; Evansville, Illinois; Oil City, Pennsylvania; and Welland, Ontario. The plant has since burned to the ground.

COLUMBIA COUNTY

Between Bloomsburg and Catawissa the North Branch of Susquehanna River makes a sharp turn, leaves the broad valley in the Helderberg limestone, passes through a narrow cut in high land formed by the sandstones and shales of Hamilton and Chemung age, and enters another valley in Catskill shale. Molding sand is dug in river terrace deposits 40 to 60 feet above the river in both the wide valleys and also on the flood plain almost at river level in the narrow cut.

Catawissa. On the Baylor farm 1 ½ miles west of Catawissa and on the D. L. & W. Railroad, a medium and a fine grade molding sand are dug for Geo. F. Pettinos, Philadelphia, from a low river terrace deposit. The sand, which is 2 to 4 feet deep (Plate XIV) and just under the soil, probably underlies several acres. It is used for many kinds of iron castings. Samples were submitted to the laboratory by Mr. Pettinos, sample No. 611 being a medium grade and No. 612 a fine grade. Sample No. 1604 of Geo. F. Pettinos, No. 1 grade was obtained by the writer from the stock bin of the Ephrata Manufacturing Co., who use it for light gray iron castings, as tin shears, gas stove burners, baking pots.

About three-quarters of a mile north of Catawissa between the tracks of the Pennsylvania and P. & R. Railroads on the very narrow flood plain of Susquehanna River, Chas. Poke digs molding sand for Chas. Pettinos, New York City. The face of the pit shows 6 to 8 inches of soil, 18 inches of subsoil with roots and small holes, then 30 to 36 inches of fine grained bonded sand. Below this is a heavy mottled sand or clayey loam. The writer cut a sample (No. 675) from the 30-inch bed in four places July 23, 1925.

Plate XIV. Molding sand pit at Catawissa, Columbia County.

Rupert. On the Mrs. S. A. Evans farm one mile southwest of Bloomsburg and ½ mile northwest of Rupert molding sand has been dug at the road forks, by W. W. Gulick, Danville. This location is a mile from the Susquehanna at the edge of the broad flood plain and about 50 feet above it. The deposit is on a terrace and may be of glacial age. It ranges in thickness from 2 feet at the edge of the terrace to 9 feet at the back of the pit. It is reported that molding sand has been found at this level for half a mile along the State Highway. According to the operator this sand is excellent for light iron castings like stove work, and some foundries use it for casting brass. Sample 635 was cut by the operator when the writer visited

the property August 8, 1924. The pit is less than a mile from sidings on the P. & R. and D. L. & W. Railroads.

CRAWFORD COUNTY

Atlantic. Less than a mile from the southern boundary of Crawford County and 5 miles east of Jamestown an unusually thick deposit of molding sand is being dug by the Superior Sand Company, Cleveland, Ohio. The pit is one mile south of Atlantic on the J. L. Pfaff farm and 500 feet from the Erie Railroad. By stripping 3 to 5

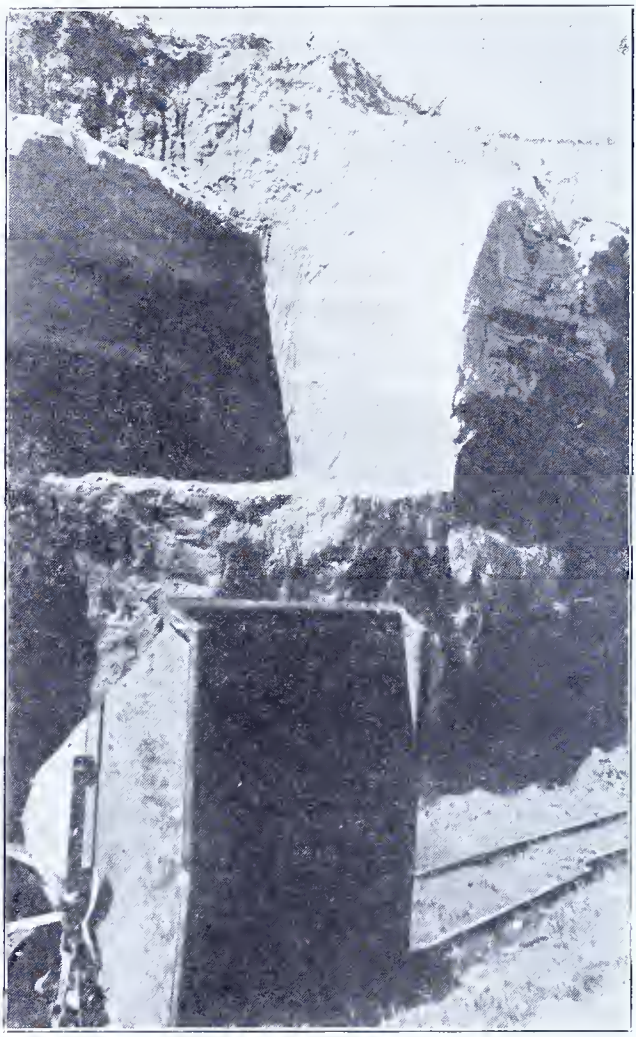

Plate XV. Thick deposit of molding sand near Atlantic, Crawford County.

feet of glacial drift the sand is uncovered and has been excavated against the slope until a face 20 feet high is exposed. When visited August 18, 1924 a clean face of molding sand 12 to 15 feet high was sampled (No. 649) and Mr. Pfaff said that at one point the sand was 20 feet thick, but the lower few feet were then hidden by filling and caving. (Plate XV).

The sand is fairly uniform grained throughout the deposit and is shipped as one grade. Bedding is more noticeable in the upper part of the deposit and may be due in part to weathering. The sand is dug by hand and shoveled directly into side dump steel cars of 1¼ yard capacity. These cars run on a 24-inch track to a private siding where they dump into open top railroad cars. The sand is dug in lifts or benches which are kept well trimmed so that the operation presents an orderly appearance. The floor of the deposit is gravel. Mr. Pfaff estimates that the deposit underlies 10 acres on his farm. According to him the sand is used by Buick Motor Company, Detroit; Enterprise Brass Works, Muskegon, Mich.; International Harvester Company, Muncie, Indiana; Bronze Metal Works and Malleable Iron Works, Meadville, Pa., and has been shipped far and wide.

The deposit is on a gentle slope about 150 feet above the swampy floor of a wide valley. Records of deep wells show that drift over 100 feet deep forms the valley floor. Other evidence indicates that in glacial time the drainage of Crawford County flowed north to the region now occupied by Lake Erie. The advance of the continental glacier dammed these north-flowing rivers and their valleys were filled with sand and gravel. This deposit of molding sand the writer believes is a remnant of the material laid down here when the valley was occupied by a broad quiet pond during the glacial period. Later the advance of the glacier resulted in drift being spread over the sand, and diversion of the drainage to the south. After the glacier retreated, erosion carried away much of the valley filling and only patches of this thick deposit of sand remain along the edges. Deposits like that near Atlantic might be found elsewhere in Crawford and Mercer counties where the streams were ponded in the glacial period.

CUMBERLAND COUNTY

Mt. Holly Springs. Cambrian quartzite outcropping along the foot of South Mountain is so decomposed in some places that it is readily crushed to sand. At Mt. Holly Springs on the south side of the village J. E. Peterson employs several men digging the soft rock by hand. It is trammed to a small Eureka crusher and elevated to a jig screen. The pebbles are used in concrete and the sand goes to Carlisle for general building purposes. As sand from adjoining pits was used by the Bethlehem Steel Company at Steelton the writer took Sample No. 674 from a truckload of unwashed building sand with the idea that this material might be suitable for steel molding.

The Silica Sand Company of Steelton, owned by the George W. Cumbler Estate, operates a silica sand quarry and washing plant 1 ½ miles east of Mt. Holly Springs on the P. & R. Railroad. At the quarry high on the mountain side the decomposed Cambrian quartzite

is broken in a small crusher and flushed down a chute to the washing and classifying plant on the railroad. This newly built plant, driven by electric power, makes three sizes of washed silica sand. The oversize from the classifier is hauled by dump wagon to the old plant and reground in a 9-foot dry pan. All of the product is shipped by rail to the region between Lebanon, Lancaster, and Waynesboro and used for building purposes. The writer took two samples from stock piles at the washer June 9, 1925. Sample No. 667 is the coarse size, probably suitable for steel molding sand, and No. 668 is the fine grade from this plant. The intermediate grade of sand was not sampled.

ELK COUNTY

Ridgway. The Gardner Sand Company of Ridgway has been producing molding sand along Clarion river for several years. According to Mr. Charles Fox, manager, the company has the river bottom lands under lease for 10 miles. In August 1924 when the writer visited the locality, bonded molding sand was being dug in the bank of the river 5 miles below Ridgway and the company had a silica sand plant at the same place for crushing Pottsville sandstone quarried on the hill high above the river. The property is on the Buffalo, Rochester & Pittsburgh Railroad and the company has private spurs for loading. The molding sand is an alluvial deposit and naturally varies in character in different parts of the flood plain. Samples were taken of loam (*No. 640) of which Mr. Fox says the company has 15 acres 10 feet deep; of No. 1 sand (sample No. 643), and of No. 4 velvet (sample No. 638). Trees and brush are removed and about 2 feet of soil stripped to uncover the sand which is 4 to 6 feet deep. At the time of visit 3 men were digging by hand and loading two 1-horse dump carts which were dumped from a platform into a railroad car. The sample of No. 4 velvet was taken from the loaded car. This sand is used for casting radiators, brake shoes and machinery. A steam shovel was being unloaded for use in digging loam. The samples of No. 1 and of the loam were prepared by Mr. Fox.

According to Mr. Fox the company also holds 65 acres of a 50-foot ledge of silica sand. This may be the Pottsville sandstone. The rock from the quarry on the mountain comes down an incline track to a plant on the railroad spur. In the plant a Lewistown jaw crusher, Stevenson 10-foot pan grinder, belt bucket elevator and flat wire screen produce 1-inch stone for chemical works and sand for steel foundries. Sample 639 was taken by the writer from the steel sand stock pile.

Silica sand for steel foundries and other uses is produced also by the Silicon Products Company, Dagucahonda, about 4 miles east of Ridgway by grinding the Pottsville (?) sandstone.

*No. 640, loam is very much like South Amboy, N. J. molding loam, No. 531.

ERIE COUNTY

During the glacial period when a great ice sheet advanced from the north and overrode Canada and the northern United States the size, outline, and level of the Great Lakes differed much from the present. Lakes formed along the front of the glacier and for long periods stood at a higher level than the lakes are now. A glacial lake stood for a long time about 200 feet higher than the present level of Lake Erie and extended one to four miles south of the present shore. Sand and mud washed into this lake and settled on its bottom made the deposits that are now being dug on the broad gently sloping land along the south shore of Lake Erie.

West Springfield. Molding sand has been dug near West Springfield for more than a quarter of a century. The Walker Sand Company of that place and the Union Sand Company of Conneaut, Ohio, are the present operators. Shipment is by the Lake Shore and Michigan Southern Railroad and the New York, Chicago, & St. Louis Railroad which parallel each other through this region. The operations are generally in open fields and consist of stripping a few inches of soil and digging about 2 feet of molding sand. Wagons are loaded by hand and hauled to a railroad siding where the sand is laboriously shoveled into a car. When a deposit has been worked out the original soil is on the surface, which is two feet lower, and the field is ready for cultivation.

The Walker Sand Company in August, 1924, was digging molding sand at several localities. One sand known as No. 1-H (Sample 644) is dug in the higher parts of a nearly level field and 130 feet above Lake Erie one mile west of Springfield Station. It occurs just under the sod, averages 2 feet thick, and is very free of pebbles. It is shipped to many customers for malleable iron castings and cores.

In the lower parts of the same field their brand No. 3-E is dug (Sample No. 645). It underlies many acres and can be taken from the whole field when the overlying No. 1-H has been removed. This sand is used in gray iron foundries for medium and heavy castings.

Almost directly on the lake shore 1 ¾ miles west of North Springfield and about 30 feet above the lake, the Walker Sand Co. digs a fine molding sand from small knolls. The sand is about 3 feet deep, has a few pebbles, but is free from cobbles, and is used for stove plate and for high grade malleable castings. This brand, No. 1-V, is represented by Sample No. 641.

The Union Sand Company of Conneaut, Ohio, was shipping sand in August, 1924, from a pit on the north side of the Yellowstone Trail 1 ¼ miles northeast of West Springfield just east of Racoon Creek at an elevation of 700 feet. A sample (No. 647) of this sand, their No. 1 ½ Hoxie, was taken from a car being loaded at Crayton,

a nearby siding on the N. Y., C. & St. L. Railroad. This sand is used for general light iron castings, including plows, and for casting bath tubs, wash basins, and other sanitary ware.

Fairview. On the south side of the N. Y., C. & St. L. Railroad tracks 1¼ miles west of Fairview and the same distance from the shore of Lake Erie and about 160 feet above the present lake a deposit of fine gravel with enough molding sand to give it some bond is dug by the Walker Sand Company of West Springfield. The deposit is 2 to 2½ feet deep and probably marks either a glacial lake beach or delta. This material is sold to foundries for ingot molds and cores. It is the Walker Sand Company's brand No. 6-FV and sample No. 646.

Northeast. It was reported at the Lakeside Hotel, on the Lake shore two miles from Northeast, that molding sand was found in excavating for the cellar. The writer dug two shallow pits in front of the hotel at an elevation calculated to uncover the same stratum as in the cellar but found only sharp sand. In the cut bank directly above the beach in front of the hotel, however, a sand was found 5 to 8 feet below the sod that seemed to be a prospective molding sand. The section considered was 3 to 4 feet thick, the upper part mottled gray and the lower part clear tan. There seemed to be more bond in the mottled sand but a sample (No. 648) was taken of the whole 4 feet. If this sand is of any value it probably could be obtained in considerable quantity, but the overburden is heavy here.

FAYETTE COUNTY

Broad Ford. One mile north of Connellsville on the west bank of Youghiogheny River and three-quarters of a mile southeast of Broad Ford Station on the Pittsburgh & Lake Erie Railroad, A. C. Edwards of Broad Ford is digging a river terrace deposit and producing sand that is used for casting iron pipe at Scottdale. When seen August 11, 1925 a cut had been made in the deposit about 100 yards long and 25 feet wide, with a face 8 to 10 feet high. Cobbles and boulders, which occur principally in the upper 3 feet of the deposit, are left in the pit. The sand and gravel is shoveled by hand to quarry cars that are drawn by a horse to the plant which consists of a simple rotary cylindrical screen with about ⅜ inch openings, and elevator. The oversize goes to a waste pile and the sand is trammed in a small car to a platform where it dumps directly into a railroad car. Power for operating the screen and belt bucket elevators is furnished by a gasolene tractor. The product is a coarse, loamy sand. Sample No. 692 was taken by the writer from a loaded car.

Connellsville. A. C. Edwards of Broad Ford has dug molding sand also in Connellsville. The locality is on the flood plain of Youghiogheny River at the north end of First and Second streets, west side,

but excavation is limited to a few undeveloped city lots, although the deposit may underlie several city blocks that are now built up. Similar sand might be found on other flats about 20 feet above the river. In fact similar deposits in West Connellsville have been worked out by Guiler and Torrence. There is little chance for further production of molding sand within the city. In the triangle at the end of First Street where the latest excavating was done, the section is: soil and sand, 2 feet; coarse gravel, 3 inches; molding sand, 4-5 feet. Sample No. 694 representing this sand was taken from the stock bin of Sypherds foundry in Connellsville. The sand is used locally for the general run of gray iron castings.

Dunbar. Silica sand produced by crushing the Pottsville sandstone that occurs high on the mountain east of Dunbar is used largely for concrete and for traction sand but is sold also to steel mills. The Dunbar Corporation operates two large quarries, one probably in the Homewood and one in the Connoquenessing sandstone. Quarry cars are loaded by hand and by electric shovel and lowered by cable tram to the mill which is on the New Haven & Dunbar Railroad. The mill is equipped with 3 jaw crushers, 3 wet pan grinders, and batteries of screw washers. The product is poured out on a big stock pile, where it is handled and loaded by two electric clamshell dredges. (Plate XVI). Sample No. 693 is a rescreened product of this plant, carrying less very fine material than the usual run.

The Dunbar Corporation also furnished a sample (No. 699) of bonded molding sand from an undeveloped deposit on the flood plain of Youghiogheny River about 5 miles east of Dunbar at Stone Hill station on the B. & O. Railroad. The writer did not visit the locality and knows nothing of the deposit.

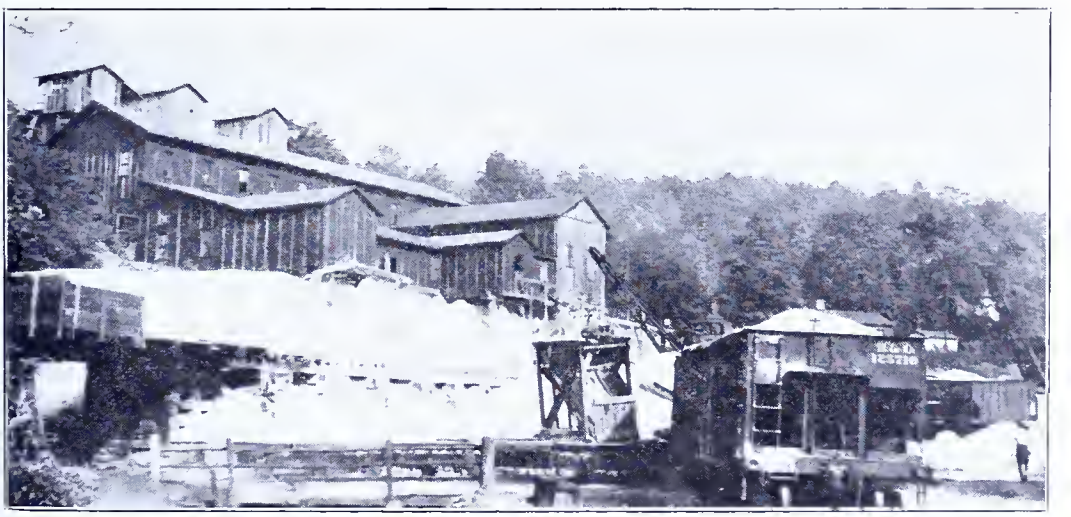

Plate XVI. Silica sand plant and stockpile at Dunbar, Fayette County.

Perryopolis. This village, named for the victor of a naval engagement on Lake Erie, and laid out with radiating and circular streets on a plan approved by George Washington, who owned 1,600 acres here, is situated on what seems to be an abandoned channel of Youghiogheny River. The bed of this channel is about 200 feet higher than the present one and was covered with a deep deposit of sand and gravel when the river was retarded or ponded by ice in the glacial period. After the retreat of the ice the land rose and the river deepened its channel, in places abandoning its former course, including a loop that encircled the site of Perryopolis. This river or pond deposit in the abandoned channel has been worked for molding sand for 20 years or more. The operations of Guiler and McIntire east of the village along the Washington Run Railroad stripped about 8 acres. Production now is by J. K. McIntire, former superintendent for the Guiler-Kendall Sand Company which is out of business. Mr. McIntire is digging sand on his farm and shipping to the U. S. Cast Iron Pipe & Foundry Company. Production is from two pits, an upper and a lower one. The face of the upper pit is 8 to 9 feet high and shows three distinct parts, sharp sand above and below with a tough bonded sand in the middle. The whole thickness is used. The face of the lower pit is 6 to 12 feet high. In some places it is almost clean sand; elsewhere there may be 3 feet of fine sand, 4 feet of cobbles and bowlders, resting on 5 feet of coarse, cross-bedded sand. The cobbles and coarse gravel are left in the pit and the rest of the deposit is shipped. The sand is dug by hand and loaded in a 1-horse dump wagon. It is hauled to a platform on a railroad siding and dumped into a car. The sand is not screened and the only mixing of sharp and bonded sand is that which occurs in the process of digging and loading.

Sample No. 695 was dug by the writer from the face of the upper pit and represents the finer sand suitable for general gray iron work; sample No. 696 was taken from a loaded car at the pit and represents the core sand used for molding cast iron pipe.

FRANKLIN COUNTY

Fayetteville. For miles across the Cumberland Valley the white scar made on the west side of South Mountain by the quarry of the Mt. Cydonia Sand Company is visible. This quarry is about two miles southeast of Fayetteville and one mile south of the Lincoln Highway. It was opened about 1913 in the weathered Cambrian sandstone behind Little Mountain and has developed to a face more than 100 feet high and 300 feet around. The stone is shot down with explosives in 20-foot drill holes, loaded with a Marion ¾-yard steam shovel into quarry cars and delivered to a sidehill crushing plant. The equipment here is a Champion crusher, an American 9-foot dry pan grinder, and

gravity screens. A spur track connects the plant with the Cumberland Valley Railroad at Pond Bank. The product is an unwashed silica sand used widely in the Cumberland Valley for general building and highway construction. Local contractors take 500 tons weekly by truck. A small quantity of the sand is sold to foundries. Sample No. 621 was taken by the writer from the stock bin at the crusher plant and Sample No. 665 from the same quarry was obtained from the stock bin of the Frog, Switch, and Manufacturing Company at Carlisle.

Pond Bank. Silica sand has been produced by Smith & Landis, Mont Alto, from a pit also in soft sandstone on the mountain side above Pond Bank, about a quarter of a mile south of the Mt. Cydonia Sand Company's quarry. They were not operating in 1925. Digging and screening was done by hand. A sample of this unbonded, unwashed silica sand (No. 623) was obtained from the stock bin of the Landis Machinery Company, Waynesboro.

Shippensburg. About 4 miles south of Shippensburg near the reservoir on Furnace Run, are the E. T. Millard Sand Works. Excavation is in mountain wash composed of red sand, cobbles, and bowlders up to 15 inches in diameter derived largely from the Antietam sandstone and Mont Alto quartzite. In the pit face seen June 2, 1925 the upper 10 feet was mostly sand and the lower 15 feet a mixture of sand and cobbles. This loose material is dug with an Osgood No. 18 steam shovel and loaded on small tram cars. In the plant this material passes through a McLanahan 24-inch roll crusher, Lewistown 9-foot pan grinder and screens, and finally through Lewistown washers. Most of the product is sold as washed building sand and is shipped by Pennsylvania and Philadelphia & Reading Railroads throughout the region between Lancaster, Pennsylvania, and Winchester, Virginia. A small quantity of this washed silica sand is sold to an iron foundry in Chambersburg for making small cores. Sample No. 620 was taken by the writer from the stock pile at Millard's plant.

Waynesboro. On the Pennsylvania-Maryland State line 2 miles southwest of Waynesboro, Little Antietam Creek has been diverted for a short distance, and in the abandoned channel A. N. Foltz of Waynesboro dug molding sand from 1902-1923 and claims to have taken out about 30,000 tons. The pits had been worked for many years before him. The sand occurs along the bottom of a swale just under the soil and may be two or three feet deep. Caving since digging stopped has largely concealed the sand, but Mr. Foltz obtained Sample No. 622 by shallow digging at several points June 4, 1925. This sand was used in Waynesboro and Chambersburg for casting agricultural machinery, engines, and flour milling machinery. The land on which the sand occurs is owned by Mrs. Sue Brown, R. D. 3, Smithburg, Maryland. The pits are in a plowed field north of her farm house and may be just over the line in Maryland.

JEFFERSON COUNTY

Falls Creek. On the eastern boundary of Jefferson County the Pottsville sandstone outcrops extensively on Falls Creek and is quarried by the Falls Creek Sand & Stone Company. The quarry is three-quarters of a mile from the railroad station on a private spur from the Buffalo, Rochester & Pittsburgh and the Pennsylvania Railroads. Many years of operation have developed a quarry face about 3,500 feet long and averaging 40 feet high. A large plant reduces the sandstone to washed and unwashed silica sand. The washed sand is used largely for grinding plate glass and the unwashed sand for molding steel. According to Morton W. Hall, manager, the plant produces 500 to 1,200 tons of sand daily and had stock piles in August 1924 of 20,000 tons. Sample No. 656 was dug by the writer from the stock pile of unwashed sand, and Sample No. 657 from the washed sand.

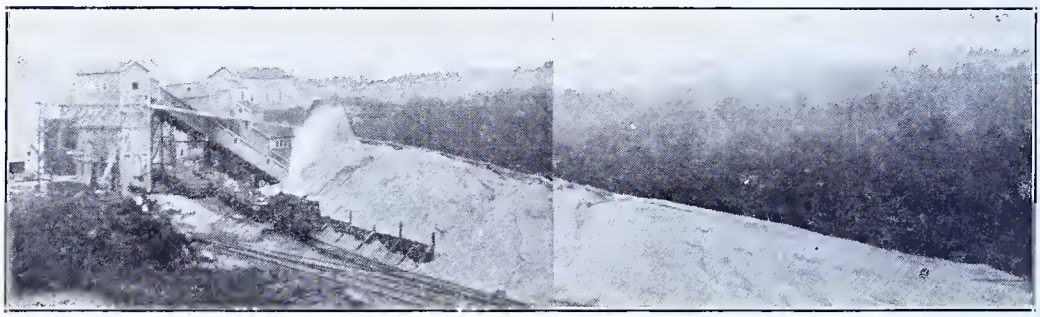

Plate XVII. Silica sand plant and stock pile at Falls Creek, Jefferson County.

LANCASTER COUNTY

Marietta. About 50 feet above Susquehanna River on the broad terrace on which Marietta is built, molding sand is dug in one place, although it may be abundant on several farms. The pit operated intermittently by the Marietta Sand Company, Henry S. Rich, manager, is on the Barclay farm half a mile west of the town and on the Pennsylvania Railroad. The molding sand is 1 to 2 feet below the surface and varies in thickness possibly up to 3 feet. It rests on sharp sand and loam. It is dug by hand and delivered by truck to foundries in Lancaster and Wrightsville for making gray iron castings, including bearings, man-holes, grates, etc. Sample No. 671 is this Marietta sand from the stock bin of the Lancaster Iron Works, Inc., and Sample No. 672 was dug by the writer at the pit west of Marietta.

Rohrerstown. Two miles west of Rohrerstown on the Lancaster-Marietta turnpike, A. C. Bowers and Sons, Lancaster R. D. 8, are making unwashed silica sand. The Chickies quartzite is quarried,

(Plate XVIII) crushed in a New Holland No. 8 jaw crusher, ground in a dry pan and New Holland rolls, making a coarse, sharp sand (Sample No. 669), and a fine-grained sand (Sample No. 670). Sand from this quarry has been used by nearby foundries, by the Pennsylvania Railroad, and by the Bethlehem Steel Company, possibly for molding. The samples were obtained by the writer June 13, 1925 from the bins at the plant.

Plate XVIII. Silica sand quarry near Rohrerstown, Lancaster County.

LEBANON COUNTY

Jonestown. At the east end of Bunker Hill, one mile southeast of Jonestown and 5 miles north of Lebanon, the Keystone Sand Products Company, of Lebanon, is quarrying and crushing an arkosic sandstone for building sand. The quarry face is 125 feet long and 40 feet high. The plant includes a 16-inch jaw crusher, New Holland rolls, a shaker screen, and bucket belt elevator to storage bins, all driven by electric power. Two sizes of sand are sold, mostly for mortar, plaster, and concrete, but some is used by iron foundries in Lebanon and Sheridan for cores. This sand is reported to contain 96 per cent silica. If it were washed it might be suitable for glass making and for steel foundry use. Samples Nos. 1602 and 1603 were collected by the writer September 17, 1925 from bins at the crushing plant.

LEHIGH COUNTY

Allentown. On the south side of the mountain a quarter of a mile east of Millers Hotel at Aineyville, a suburb of Allentown, Mr. F. A. J. Miller has been digging the disintegrated gneiss and dry screening it by hand. Different grades of sand, some sharper than others, are obtained in different parts of the pits. The operator says that this granular gneiss is shipped by the carload to the Traylor Engineering Company, Allentown, and to the Kutztown Foundry and Machine Company, for cores. The pit is one mile from the Philadelphia & Reading and Lehigh Valley railroads. Sample No. 607 was taken by the writer from a loaded wagon at the pit.

Emaus. One mile north of Emaus and a quarter of a mile from the P. & R. Railroad, the mountain outwash apron has been opened for building sand by C. O. Hunsicker, Allentown. In the bottom of the pit a molding sand was encountered. A market was found in Allentown where this sand has been used by Kline Hardware Company and W. F. Masser & Sons for light iron castings and by Adelaide Brass Works for casting brass, bronze, and aluminum. The depth of the molding sand and its extent was not determined when the writer visited the locality in July 1923 and obtained sample No. 608, which was dug by the pit boss.

Slatedale. On the farm of P. L. Rex, three-quarters of a mile northeast of Best station on the P. & R. Railroad, a sand pit discloses 10 feet of yellow building sand. Under this is an irregular band of red clay several inches thick and below it several feet of an even-grained, slightly bonded sand that has been used in several foundries. Three feet of this sand is exposed and Sample No. 606 was cut from it in 10 places. The owner says that the molding sand goes much deeper. It was used by the Bethlehem Foundry & Machine Company, Easton Foundry & Machine Company, North Wales Foundry Company, many years ago but the pit has not been operated for molding sand in recent years. This farm is 1½ miles southeast of Slatedale.

LYCOMING COUNTY

Montoursville. Foundry sand produced by the Lycoming Silica Sand Company is a disintegrated sandstone that is dug 1½ miles east of Montoursville and north of the Susquehanna Trail. A narrow gauge track that crosses the highway leads to the pit. The sand is dug with a Byers clamshell dredge that empties into a portable hopper over the quarry track (Plate XIX). One-ton tram cars loaded from the hopper are drawn by gasolene motor to a siding on the P. & R. Railroad. The sand is not screened or washed. The sample (No. 602) was taken by the writer from several tram cars. According to Mr. J. A. Heim, general manager of the company, this sand is used for cores or steel casting by the Bethlehem Steel Company at Lebanon

and Steelton; Vulcan Iron Works, Wilkes-Barre; Lycoming Motors Corp. and Standard Heating Company, Williamsport; Kennedy Valve Company, Elmira, N. Y. and by numerous small foundries in central Pennsylvania.

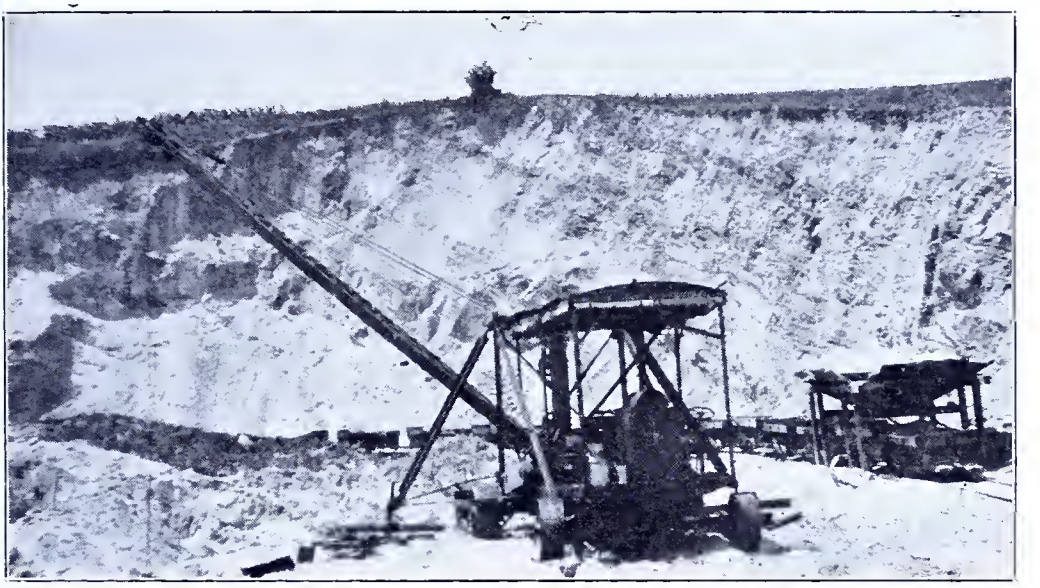

Plate XIX. Silica sand quarry at Montoursville, Lycoming County.

McKEAN COUNTY

Hutchins. On the high plateau in Sergeant Township, southern McKean County, at Hutchins on the B. R. & P. R. R., Eastern Clay Products, Inc., successors to the New York and Pennsylvania Clay Products Company, has 600 acres which they say includes 450 acres of coal, clay, and molding sand. When the writer visited the property August 12, 1924, trees, brush and soil were being stripped and a few feet of weathered sandstone dug by an Erie $^{3}/_{4}$-yard caterpillar steam shovel. This sandstone was crushed and ground for molding sand and a bed of coal immediately under it was used for raising steam. Flint clay underlying the coal was being mined underground and could be dug by steam shovel after the coal and sandstone are removed. According to S. F. Walton of the company, the sand is marketed in different sizes known as Nos. 10, 16, 20, 30, 40, and 50, to correspond with the sizes of the screens on which they are prepared. The original company prepared and sent samples of five of these sizes to the laboratory and they are respectively Sample Nos. 658-662. Sample No. 658 passes a 16 mesh screen and is said to be used by the American Car Wheel Company. Nos. 659, 660, and 661 are for general jobbing in iron castings, and No. 662 which passes a 50 mesh screen, is used for brass and stove plate work. Their coarsest product, a No. 10 sand, is suitable for casting iron pipe. This sand was not tested.

These molding sands are prepared by primary breaking in a roll crusher, grinding in Stevenson 9-foot pans, and sizing with Hummer screens. They are tempered in a pug mill to keep down dust in handling and to facilitate retempering in the foundry. This is an unusual case of a sandstone having sufficient natural bond to make an iron molding sand.

MERCER COUNTY

Greenville. A white unbonded sand said to be 97 to 99 per cent silica is produced by the Greenville Silica Products Company, and sold for building, traction, silica and steel sand. It is produced by crushing the Pottsville sandstone which is quarried 1½ miles south of Greenville on the Mercer road opposite the country club and directly on the Bessemer Railroad. The quarry, which is on top of a hill, is about 400 feet long, 100 feet wide, and 20 to 30 feet deep (See Plate XX). The rock is broken in a Champion No. 5 jaw crusher, reduced to sand in a pan grinder, screened, and washed in McClaren 22-inch screw washers. The sand commonly produced and sold as "high fuse" silica sand is represented by sample No. 650 which the writer took from the stock pile. Sample No. 651 is finer grained and can be made on demand, and No. 652 is the fine sand and clay carried to a settling yard by the first run of wash water.

Plate XX. Silica sand quarry at Greenville, Mercer County.

MIFFLIN COUNTY

Burnham. Three miles north of Lewistown at Burnham on the Milroy Branch of the Pennsylvania Railroad is the silica sand plant of J. H. Miller of Lewistown. Mr. Miller quarries the rather soft Oriskany sandstone on a ridge about 1 mile northeast of his plant

and 300 feet above it. The rock and sand is hauled in steel quarry cars by electric (trolley) motor on a light track to the plant where building sand and steel molding sand are prepared. Sample No. 601 was taken by the writer from stock at the plant July 9, 1923 that was washed, and delivered by belt conveyor to freight cars.

MONTOUR COUNTY

Danville. Back of a barn on the grounds of the State Hospital for the Insane in the eastern outskirts of Danville, a pit with a face several rods long has been opened on a bed of molding sand 3 to 10 feet thick. This is in a gently sloping field 50 or more feet above the Susquehanna River and may have been deposited during the glacial period in ponded water that occupied the valley at that time. At least the fine, even grain of the sand suggests that it was laid down in quiet water. This sand is dug by W. W. Gulick, Danville, under lease from the Commonwealth.

One foot or more of soil is removed, the sand is dug by hand, and hauled in wagons to the railroad (P. & R. and D. L. & W. Railroads). It is used largely for casting light ornamental iron, small hardware, and brass. It is sold widely over the State and goes as far north as Rochester, N. Y. and south to Norfolk, Virginia.

Sample No. 634 represents this sand, which is Gulick's brand AAA-H. The sample was dug from the pit by the operator at the time of the writer's visit August 8, 1924. The Gulick Sand Company operates in Northumberland County also.

The Danville Stove & Manufacturing Company dug a large quantity of molding sand on the State Hospital grounds close to the pit operated by the Gulick Sand Company about 1920 and hauled it across the road to a stock pile on their own land. The pit face is said to have been 12 feet deep, all in molding sand. Sample No. 679 was taken by the writer from the bin at the foundry which is filled from the outside stock pile. This sand is used for stoves, furnaces, and gas ranges.

The Art Bronze and Iron Works, Danville, makers of ornamental screens or enclosures for banks, elevators, stairways, etc., use a small quantity of sand dug alongside their foundry for opening up other sands. Sample No. 680 from their stock pile was riddled through a No. 8 screen.

Samuel C. Loreman has dug several grades of bonded molding sand on his farm 5 miles southeast of Danville and 3 miles west of Catawissa for the Gulick Sand Company, Danville. This farm is at the mouth of Roaring Creek on the south bank of Susquehanna River and has a siding on the Pennsylvania Railroad. This deposit is between 20 and 40 feet above the river and probably is of fluvial origin. The different grades of sand are found at slightly different levels in the

same field. The soil is stripped and the sand is dug and loaded by hand into wagons. The depth of the sand ranges from 3 to 7 feet. Sample No. 676, dug by Mr. Loreman in a pit just north of his orchard is of a sand about stove plate grade. Sample No. 677 taken at the edge of the orchard is coarser grained. Sample No. 678 was dug from the pit behind the schoolhouse. This sand may be less permeable than the others and is suggested for fine iron castings and aluminum. This sample was cut from a 5-foot face.

NORTHUMBERLAND COUNTY

Riverside. Across the Susquehanna from Danville is South Danville or Riverside on the Sunbury Division of the Pennsylvania Railroad. Here is a broad plain extending from the bridge down stream more than two miles and rising gently from the river barely 80 feet in more than a mile. This roughly elliptical area in the bend of the river is underlain with deposits of fine sand and has been yielding molding sand for nearly 40 years. Clean faces of sand in the pits show homogenous texture, little evidence of bedding, and suggest quiet water sedimentation.

Evidently the Susquehanna at one time flowed at a higher level but whether this sand was deposited in it or on the flood plain before the river had cut its channel to its present depth, or when the level had temporarily been raised by aggradation or by damming and ponding has not been determined. It may be that these deposits are parts of a considerable fill and the highest sand was the last laid down; or they may be normal flood plain deposits and the highest sand bed is the oldest.

It is said that the presence of molding sand in this locality was first recognized by some molders who happened along when a cellar was being dug on the old Gulick farm. Many fields have been stripped of their molding sand but the Gulick Sand Company, the only producer in the vicinity, has large holdings. Customarily from 10 to 12 inches of soil is stripped; the sand is dug by hand, loaded in wagons, and hauled less than half a mile to a railroad siding. The samples were dug from clean faces of the pits by the operator in the presence of the writer August 8, 1924.

Sample No. 631, representing Gulick's brand medium B-G, is from a fresh-cut bank in an open field a few rods from a farm house on the road about 1 mile west of Riverside station. The molding sand is 30 to 36 inches deep, without apparent bedding, and rests on a layer of small gravel. This sand is used for medium weight castings of all kinds by the foundries and boiler works in Williamsport and other cities. Sample No. 666 is brand B-G, same as No. 631, from the stock pile of the Carlisle Foundry Company.

Sample No. 632 (brand A-D) is from a pit about 2 miles southwest of Riverside station in a field on a Gulick farm south of the highway. Ten inches of soil is removed and 5 ½ feet of sand taken. The sand appears to be the same from top to bottom of the bed. It is used for casting stove plates and other light iron work; also for brass and bronze. Within a few rods is another pit, at a slightly lower level, which produces a sand sold almost exclusively for molding radiators. A sample of this radiator sand was not taken.

Sample No. 633, Gulick's brand AAA-G, is dug just a little farther from town on the crest of the low ridge on the east side of Kips Run. This pit has the deepest sand in the vicinity. Below one foot of soil, the pit face exposes what appears to be a single bed of sand 6 to 9 feet deep (Plate XXI). There is little variation from top to bottom and the quantity that can be recovered from an acre is enormous.

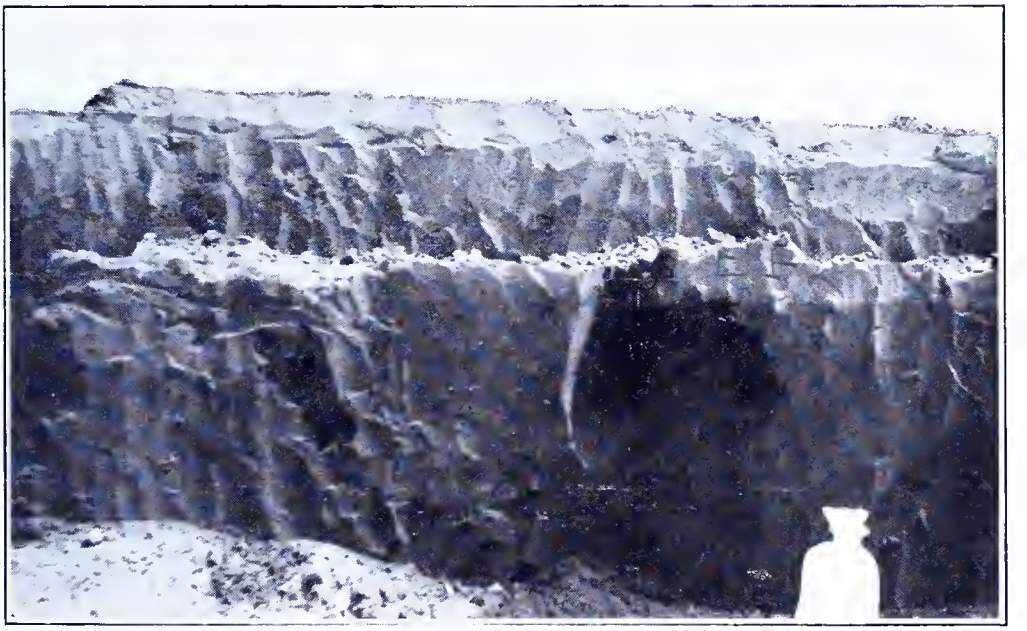

Plate XXI. Molding sand at Riverside, Northumberland County.

Excavation stops at clay, sharp sand, or gravel which occurs below the molding sand. The floor of the sand deposit slopes toward the river. This brand is sold to foundries making light and finely detailed iron, brass, and aluminum castings.

Sample No. 343 was collected by Prof. H. Ries at a stove works in Basic City, Virginia, and was reported to be Gulick's AAA-G.

VENANGO COUNTY

Emlenton. The Richland Sand Products Company, Park Building, Pittsburgh, produces silica sand near Emlenton which is on Allegheny River and Pennsylvania Railroad in the southeast corner of Venango County. The writer has not visited this locality but understands that

a sandstone at the base of the Carboniferous system, possibly the Pottsville sandstone, is quarried, crushed, ground, and washed to produce silica sand. Sample No. 618 was furnished by the producer, with the information that this sand has been used for molding steel in the Pittsburgh district by the American Steel Foundries, Mackintosh-Hemphill Company, United Engineering & Foundry Co., and Verona Steel Castings Company. Sample No. 619 from the same producer is a coarser, whiter sand from another part of the quarry.

Polk. Two miles southwest of Polk on the New York Central and Pennsylvania Railroads is the silica sand plant of the Dick Sand Company, Franklin. The plant is on the flat between the railroads and Sandy Creek and the quarry is high in the hill on the north side of the creek. The quarry face, which is several hundred feet long, exposes about 50 feet of horizontal beds of sandstone, probably of Pottsville age. A steam churn drill, steam shovel, Plymouth 6-ton gasolene motor, and heavy steel side-dump cars are the principal equipment in the quarry. The quarry product is lowered to the plant in trains of three cars on a gravity incline. At the plant the rock passes through a jaw crusher, shaking screens, rolls, Hummer vibrating screen, and Jeffreys pulverizer. Only one grade is produced, an unwashed silica sand, and all is distributed by gantry crane on a stock pile along the railroad where it can easily be loaded by belt conveyors into cars. Most of the sand goes to steel foundries including Pittsburgh Steel Foundry Company and Gould Coupler Company. Sample No. 653 was taken by the writer from the stock pile at the plant.

Oil City. On a terrace about 50 feet above Allegheny River along Colbert Avenue in the Tenth ward of Oil City, Geo. A. Ready digs molding sand which he sells to the American Radiator Company and other foundries. The deposit underlies several city lots in the immediate neighborhood. The pit face as exposed August 20, 1924 was 3 to 8 feet high; the upper part a mottled loam and the lower part gray sand. Mr. Ready says that by mixing in different proportions he prepares more open or more heavily bonded sand as desired. All digging, mixing and loading is by hand to wagons. The pit adjoins the Erie and Pennsylvania Railroads. Sample No. 654 represents the mixture commonly shipped.

Along the railroad track at the lower side of the Colvert Avenue sand pit a fine grained yellowish sand of strong bond can be uncovered by a little digging. This sand should underlie the whole tract from which the sand represented by Sample No. 654 is being taken. No. 655 is a sample of this fine yellow sand, which had not been marketed up to 1924.

Utica. The Venango Sand Company of Franklin is a large producer of steel molding sand from a quarry 5 miles west of Franklin

and 1 ½ miles east of Utica. The quarry is in sandstone of Pottsville age and when visited August 20, 1924 had a face 600 feet long and 65 feet high. The sandstone lies practically horizontal just under the flat hilltop 400 feet or more above French Creek. An Erie ¾-yard steam shovel strips the glacial drift, a churn drill makes the holes for blasting, the stone is loaded in 3-ton quarry cars which are lowered 400 feet by cable on an incline to the crushing and grinding plant at the foot of the hill on the Erie Railroad. The rock goes through a Traylor bulldog 28 by 36 inch jaw crusher, American ring and hammer pulverizer, and Hummer screens. The sand is not washed and only one grade is produced. Jones & Laughlin Steel Company, Pittsburgh; Erie Steam Shovel Company, Erie; and foundries in Buffalo, N. Y. are the larger users of this sand. A sample was not obtained for testing but this sand should be much like Sample No. 653 from a quarry at Polk.

WESTMORELAND COUNTY

Blairsville Intersection. On the flood plain of Conemaugh River one mile northwest of Blairsville Intersection (Torrance P. O.) molding sand was formerly dug by the West Penn Sand Company, of Indiana. Perhaps two acres were stripped of molding sand but it is possible that the sand underlies many acres of the broad flood plain between Torrance and Cokeville. The molding sand is about 3 feet thick, and is under two feet of soil and subsoil. It was screened in a small plant to take out pebbles. A short spur track from the Pennsylvania Railroad entered the pit.

Sample No. 685 was cut in the face of the pit at one place by the writer. Mr. Frederick, secretary of the former company at Indiana, says they used to produce three or more grades and the sample probably represents their No. 2.

Cokeville. C. L. Tittle, foundryman at Blairsville, making principally plate glass grinders and medium weight iron castings, molds his castings in a sand that he digs on the south bank of Conemaugh River just west of Cokeville at the mouth of McGee Run. It is in a knoll only a few feet above the general level of the flood plain and less than an acre in extent. The molding sand is 3 to 4 feet deep, overlain by two feet of loam and resting on sharp sand. Production is merely to supply the needs of one small foundry. Sample No. 684 of this sand at Cokeville was taken from the stock pile at the foundry. This sand has given satisfaction for a number of years. Probably other deposits could be found on the flood plain of Conemaugh River and close to the Pennsylvania Railroad.

Derry. The American Window Glass Company and the Derry Glass Sand Company at Derry have developed large quarries in white sandstone high on the west flank of Chestnut Ridge east of the town.

The sandstone is of Pottsville age and is practically free from iron. Neither of the quarries was operated in the summer of 1925. The product of both was a washed silica sand. Sample No. 693 is sand from the Derry Glass Sand Company, used by the Conemaugh Iron Works Company at Blairsville, makers of sanitary ware. They use it for cores. The sample was taken from the stock pile at the foundry.

Gratztown. Gratztown is a village on Youghiogheny River at the mouth of Sewickley Creek. Here on a bench about 150 feet above the river, the Gratztown Sand Company, 1507 Kennan Building, Pittsburgh, is digging a coarse, bonded sand. The property, 43 acres, was bought from the Guiler Sand Company in 1923 by J. S. Criste, who operates under the name Gratztown Sand Company. The deposit was made by the river before it had cut its channel to the present depth or when that channnel was filled by aggradation during ponding of the river in the glacial period.

The pit has a face 25 feet high. The upper part is a dark yellow and gray sand alternating, but yellow predominating, with a few cobbles and pebbles. The lower six feet is a gray, sharp sand. All is used in one mixture. The sand is dug by hand and loaded in steel quarry cars which dump on a stock heap with a belt conveyor beneath it. The belt carries the sand to a heavy wire mesh rotary cylindrical screen with ¼ and ½ inch openings. Gravel which will not pass the screen goes to a waste pile and all the sand goes to a stock pile from which a belt conveyor delivers it to a chute 175 feet long that carries the sand down the hillside and empties into cars on a siding on the B. & O. Railroad. The machinery is driven by two natural gas engines.

This sand has been used by the Hempfield Foundry Co., Greensburg; National Tube Company, McKeesport; Standard Engineering Company, Elwood City; and other gray iron foundries in the Pittsburgh district. The writer took a sample (No. 697) from the stock pile at Gratztown by digging a shovelful from several places around the base, and another (No. 691) from the stock bin of the Hempfield Foundry Company, Greensburg.

Hunkers. The Saltsburg sandstone has been quarried for building stone and for sand at Hunkers, a station on a branch of the Pennsylvania Railroad nine miles south of Greensburg. The quarry is on the crest of a hill one mile southeast of the village. The Hunkers Sand & Stone Company is now quarrying a ledge of soft, white to pink, sugary sandstone in this old quarry. The quarry product goes to a plant at the end of a railroad spur, where it goes through a jaw crusher, 9-foot wet pan grinder and screen, and Lewistown washers. The daily output is 5 or 6 cars of washed, yellow silica sand, some of which goes to foundries for steel and core sand. Sample No. 689 is this Hunkers sand from the stock bin of a foundry in Greensburg.

Ruffs Dale. On the flood plain of Sewickley Creek 4 miles northwest of Ruffs Dale, and half a mile west of Walts Mill on the farm of Ed. Bollinger there is a prospective deposit of bonded molding sand. Mr. Bollinger has tested the ground and believes that 30 acres of river flat is underlain by molding sand. He says it is free of stones to a depth of six feet but the sand gets sharper with depth. It has been used by Scottdale and Mt. Pleasant foundries and by the local Yukon foundry (now defunct), for casting man holes, street grates, window weights, etc. Sample No. 698 was taken by the writer in the field by the bridge on the concrete highway near the Bollinger farm house. After removing 8 inches of soil, a sample was dug of 18 inches of bonded sand beneath. Sharp sand lay below. This field is only a quarter of a mile from a siding on the Pennsylvania Railroad.

YORK COUNTY

Dover. Along Fox Run, a branch of Little Conewago Creek near Dover, the wash from disintegration of the Triassic sandstone and shale accumulated on the flood plain, has been dug for use in foundries in York. E. D. Fickes digs a clay on his farm for daubing cupolas and on neighboring farms digs molding sand on the bank of Fox Run. The pits are very small and no fresh faces were exposed when the locality was visited. Soil is removed and a few wagon loads of sand taken when required. Sample No. 663 was taken by the writer from a stock heap of sand dug by Fickes on the George Lauer farm. It is used by the York Manufacturing Company to mix with other sand for casting ice-making machinery.

S. H. Croan of Dover also has produced molding sand occasionally on his farm 2 miles east of Dover where a country road crosses Fox Run. The fine red sand along the bank of the run is derived from the Triassic sandstone and shale, and is accumulated in small quantity. Sample No. 664 dug by Mr. Croan represents the sand he occasionally supplies to the York Manufacturing Company and York Safe & Lock Company.

If these sands near Dover are usable it is likely that similar material in larger quantity can be found on the banks of the larger streams in these same rocks.

Newmarket. On the south bank of Yellow Britches Creek near Newmarket at the extreme northern tip of York County on a Susquehanna River terrace, a pit has been opened to supply sand for brick molding. It is operated by Mr. E. E. Fleurie, brick manufacturer of New Cumberland. The pit face, 8 to 10 feet high, shows 4 feet of dry sandy loam under the sod, then about 4 feet of fine-grained, slightly mottled red and tan bonded sand, resting on tan-colored fine grained sharp sand. The writer cut a sample (No. 673) from 3 places in the

lower half of the bonded sand just above the sharp sand. This locality is a short half mile south of the bridge at New Cumberland on the road to York.

OTHER STATES

Several tests of sand produced in New Jersey, New York, and Ohio are included at the end of the tests of Pennsylvania sand. Most of these are from the Transactions of the American Foundrymen's Association, vol. 32, pt. 2, 1925, which contains tests of sand from several States. The tests republished here were selected because they are similar to those of some Pennsylvania sands.

LIST OF SAMPLES

In the following list the laboratory numbers of the samples are in order, and the name of the producer or owner is given, together with the locality where the sand occurs. This list will be useful in connection with the accompanying map, Figure 10.

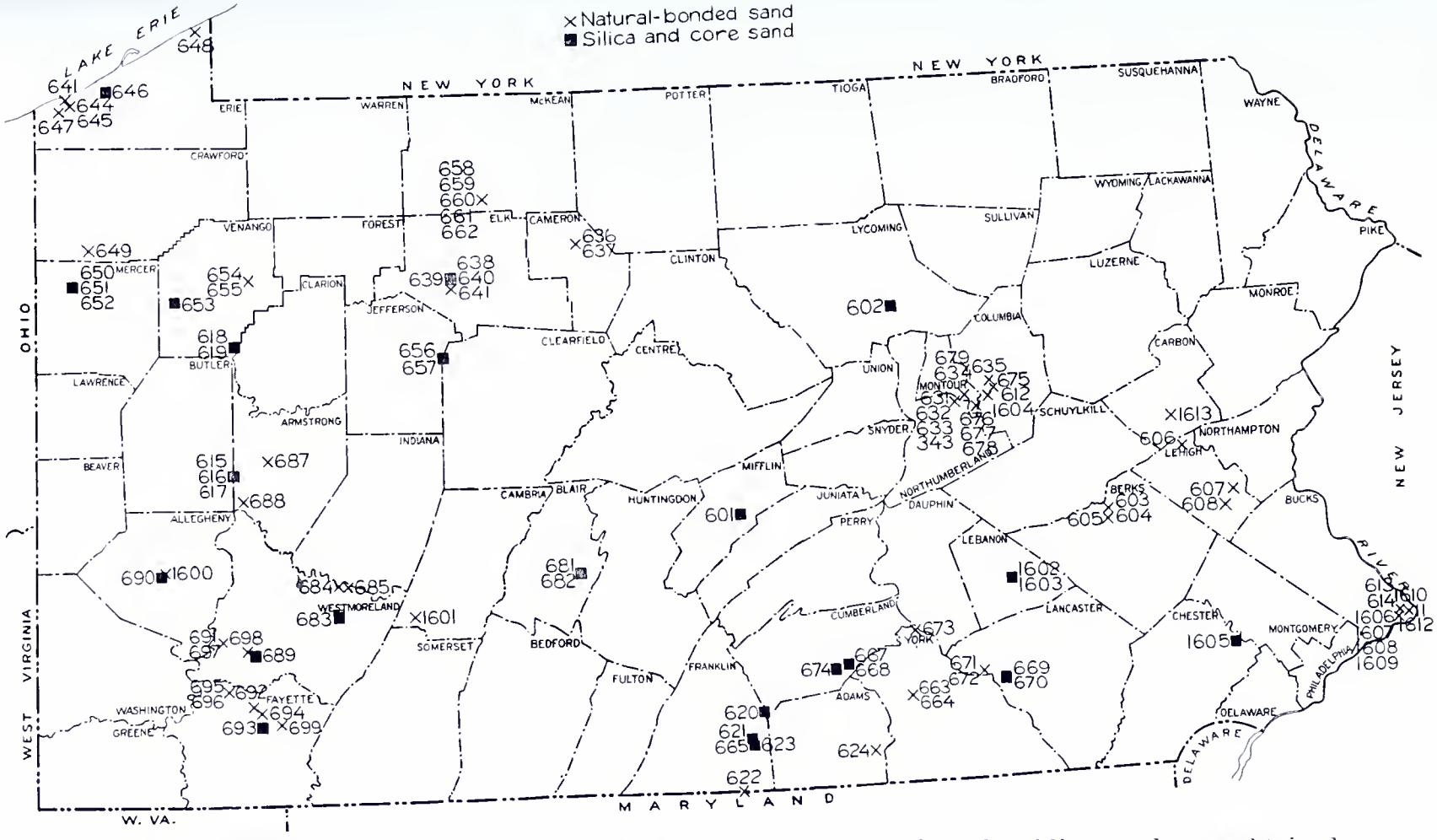

Fig. 10. Map of Pennsylvania showing localities where samples of molding sand were obtained.

LIST OF SAMPLES

B=bonded, S=silica or steel, C=core.

No.	Kind	Producer or owner	County	Town
601	S	J. H. Miller, Lewistown	Mifflin	Burnham
602	S	Lycoming Silica Sand Co. Montoursville	Lycoming	Montoursville
603	B	C. S. Saylor, Philadelphia	Berks	Hamburg
604	B	C. S. Saylor, Philadelphia	Berks	Hamburg
605	B	Schuylkill Valley Sand Co. Berne	Berks	Berne
606	B	P. L. Rex, Slatedale	Lehigh	Slatedale
607	C	F. A. J. Miller, Allentown	Lehigh	Aineyville
608	B	C. O. Hunsicker, Allentown	Lehigh	Emaus
611	B	Geo. F. Pettinos, Philadelphia	Columbia	Catawissa
612	B	Geo. F. Pettinos, Philadelphia	Columbia	Catawissa
613	B	Geo. F. Pettinos, Philadelphia	Bucks	Tulytown
614	B	Geo. F. Pettinos, Philadelphia	Bucks	Tulytown
615	S	Winfield Sand Co., Pittsburgh	Butler	West Winfield
616	S	Winfield Sand Co., Pittsburgh	Butler	West Winfield
617	S	Winfield Sand Co., Pittsburgh	Butler	West Winfield
618	S	Richland Sand Products Co., Pittsburgh	Venango	Emlenton
619	S	Richland Sand Products Co., Pittsburgh	Venango	Emlenton
620	S	E. T. Millard Sand Works, Shippensburg	Franklin	Shippensburg
621	S	Mt. Cydonia Sand Co., Fayetteville	Franklin	Pond Bank
622	B	A. N. Foltz, Waynesboro	Franklin	Waynesboro
623	S	Smith and Landis, Mont Alto	Franklin	Pond Bank
624	C	F. B. Frock, McSherrytown	Adams	McSherrytown
631	B	W. W. Gulick, Danville	Northumberland	Riverside
632	B	W. W. Gulick, Danville	Northumberland	Riverside
633	B	W. W. Gulick, Danville	Northumberland	Riverside
634	B	W. W. Gulick, Danville	Montour	Danville
635	B	W. W. Gulick, Danville	Columbia	Catawissa
636	B	Oscar Heath, Emporium	Cameron	Emporium Jct.
637	B	Oscar Heath, Emporium	Cameron	Emporium Jct.
638	B	Gardner Sand Co., Ridgway	Elk	Ridgway
639	S	Gardner Sand Co., Ridgway	Elk	Ridgway
640	B	Gardner Sand Co., Ridgway	Elk	Ridgway
641	B	Walker Sand Co., West Springfield	Erie	North Springfield
643	B	Gardner Sand Co., Ridgway	Elk	Ridgway
644	B	Walker Sand Co., West Springfield	Erie	Springfield
645	B	Walker Sand Co., West Springfield	Erie	Springfield
646	C	Walker Sand Co., West Springfield	Erie	Fairview
647	B	Union Sand Co., Conneaut, Ohio	Erie	West Springfield
648	B	Lakeside Hotel, Northeast	Erie	Northeast
649	B	Superior Sand Co., Cleveland, Ohio	Crawford	Atlantic
650	S	Greenville Silica Products Co., Greenville	Mercer	Greenville
651	S	Greenville Silica Products Co., Greenville	Mercer	Greenville
652	S	Greenville Silica Products Co., Greenville	Mercer	Greenville
653	S	Dick Sand Co., Franklin	Venango	Polk
654	B	Geo. A. Ready, Oil City	Venango	Oil City
655	B	Geo. A. Ready, Oil City	Venango	Oil City
656	S	Falls Creek Sand & Stone Co., Falls Creek	Jefferson	Falls Creek
657	S	Falls Creek Sand & Stone Co., Falls Creek	Jefferson	Falls Creek
658	B	Eastern Clay Products Co., Inc., Ridgway	McKean	Hutchins
659	B	Eastern Clay Products Co., Inc., Ridgway	McKean	Hutchins
660	B	Eastern Clay Products Co., Inc., Ridgway	McKean	Hutchins
661	B	Eastern Clay Products Co., Inc., Ridgway	McKean	Hutchins
662	B	Eastern Clay Products Co., Inc., Ridgway	McKean	Hutchins
663	B	E. D. Fickes, Dover	York	Dover
664	B	S. H. Croan, Dover	York	Dover
665	S	Mt. Cydonia Sand Co., Fayetteville	Franklin	Pond Bank
666	B	W. W. Gulick, Danville	Northumberland	Riverside
667	S	Silica Sand Co., Steelton	Cumberland	Mt. Holly Springs
668	S	Silica Sand Co., Steelton	Cumberland	Mt. Holly Springs
669	S	A. C. Bowers & Sons, Lancaster	Lancaster	Rohrerstown
670	S	A. C. Bowers & Sons, Lancaster	Lancaster	Rohrerstown
671	B	Marietta Sand Co., Marietta	Lancaster	Marietta
672	B	Marietta Sand Co., Marietta	Lancaster	Marietta
673	B	E. E. Fleurie, New Cumberland	York	New Market
674	S	J. E. Peterson, Mt. Holly Springs	Cumberland	Mt. Holly Springs
675	B	Chas. Pettinos, New York City	Columbia	Catawissa
676	B	Samuel C. Loreman, Catawissa	Montour	Roaring Creek
677	B	Samuel C. Loreman, Catawissa	Montour	Roaring Creek
678	B	Samuel C. Loreman, Catawissa	Montour	Roaring Creek
679	B	Danville Stove & Mfg. Co., Danville	Montour	Danville
680	C	Art Bronze & Iron Works, Danville	Montour	Danville
681	S	W. M. Cronister, Altoona	Blair	Mines
682	C	W. M. Cronister, Altoona	Blair	Mines
683	S	Derry Glass Sand Co., Derry	Westmoreland	Derry
684	B	C. L. Tittle, Blairsville	Westmoreland	Cokeville
685	B	West Penn Sand Co., Indiana	Westmoreland	Blairsville Int.
686	B	West Albany Molding Sand Co., Albany, N. Y.		

B=bonded, S=silica or steel, C=core.

No.	Kind	Producer or owner	County	Town
687	B	Hoey & Gallaher, Kittanning	Armstrong	Kittanning
688	B	Undeveloped	Armstrong	Freeport
689	S	Hunkers Sand & Stone Co., Hunkers	Westmoreland	Hunkers
690	C	J. K. Davison Company, Pittsburgh	Allegheny	Pittsburgh
691	B	Gratztown Sand Co., Pittsburgh	Westmoreland	Gratztown
692	C	A. C. Edwards, Broad Ford	Fayette	Broad Ford
693	S	Dunbar Corporation, Dunbar	Fayette	Dunbar
694	B	A. C. Edwards, Broad Ford	Fayette	Connellsville
695	B	J. K. McIntire, Perryopolis	Fayette	Perryopolis
696	C	J. K. McIntire, Perryopolis	Fayette	Perryopolis
697	B	Gratztown Sand Company, Pittsburgh	Westmoreland	Gratztown
698	B	Ed. Bollinger, Ruffs Dale	Westmoreland	Walts Mill
699	B	Dunbar Corporation, Dunbar	Fayette	Stone Hill
1600	B	James Jiles Company, Pittsburgh	Allegheny	Pittsburgh
1601	B	Lorain Steel Co., Johnstown	Cambria	Johnstown
1602	S	Keystone Sand Products Co., Lebanon	Lebanon	Jonestown
1603	S	Keystone Sand Products Co., Lebanon	Lebanon	Jonestown
1604	B	Geo. F. Pettinos, Philadelphia	Columbia	Catawissa
1605	S	Valley Forge Sand Co., Valley Forge	Chester	Valley Forge
1606	B	J. W. Paxson Co., Philadelphia	Bucks	Tullytown
1607	B	J. W. Paxson Co., Philadelphia	Bucks	Tullytown
1608	B	J. W. Paxson Co., Philadelphia	Bucks	Tullytown
1609	B	J. W. Paxson Co., Philadelphia	Bucks	Tullytown
1610	B	Brennan Sand Co., Tullytown	Bucks	Tullytown
1611	B	Brennan Sand Co., Tullytown	Bucks	Tullytown
1612	B	Brennan Sand Co., Tullytown	Bucks	Tullytown
1613	B	Louis Kemp, Allentown	Carbon	Lehighton
343	B	W. W. Gulick, Danville	Northumberland	Riverside

TESTS OF PENNSYLVANIA FOUNDRY SAND.

The following 103 tests of foundry sand in Pennsylvania were made under the direction of Prof. H. Ries at Cornell University, Ithaca, New York, and at the expense of the American Foundrymen's Association. These are in two groups, (1) natural-bonded molding sands, including a few used for cores, and (2) silica sands used for steel casting. This second group includes also a washed river sand from Pittsburgh and gravel from Fairview, Erie County, which are used for cores, and fine-grained sand from certain sand grinding plants.

Tests of natural-bonded molding sands.

Lab. No.	County	Grade or use	Screen analysis											Dye Adsorption	Water per cent	Bond strength	Permeability	Compression lbs. per sq. in.	Tensile strength lbs. per sq. in.
			On 6	On 12	On 20	On 40	On 70	On 100	On 140	On 200	On 270	Through 270	Clay	Total						
1600	Allegheny	Core		2.08	8.20	28.24	13.48	4.26	3.48	2.74	3.30	6.60	27.56	99.94		9.6	300	236	14.8	1.42
																11.4	303	243	11.7	1.23
																12.1	260	193	10.9	1.00
1600	Allegheny	Dry sand	9.08	9.04	3.34	10.04	13.34	4.98	3.28	2.04	3.40	14.04	27.54	100.12		7.1	271	62	12.4	0.87
																9.0	304	148	10.8	0.87
																9.9	320	55	10.4	0.87
688	Armstrong	Not used			0.64	2.14	1.86	1.54	1.94	2.20	6.74	5.00	47.56	99.62		7.9	250	3.3	13.8	0.77
																10.0	272	4.0	13.2	0.81
																12.7	300	5.1	11.4	0.68
																13.6	----	6.7	----	----
687	Armstrong					1.00	23.10	20.10	15.00	7.84	8.70	12.26	11.90	99.84		3.9	147	21.0	5.0	0.26
																6.4	156	34.0	5.0	0.32
																8.7	144	47.0	4.0	0.32
																9.4	----	42.0	----	----
603	Berks			.04	.70	5.58	14.32	12.98	10.12	5.88	7.80	13.92	28.90	100.24		5.8	219	----		
																6.4	294	4.7		
																8.5	288	10.7		
																10.4	253	27.0		
																12.3	----	10.7		
604	Berks			.20	.22	5.48	34.48	15.40	8.98	4.78	5.74	8.28	16.44	100.00		4.3	175	15.7		
																6.2	201	36.0		
																8.3	182	62.0		
																9.9	----	44.0		
605	Berks			.20	.26	2.00	5.66	6.70	8.92	6.16	9.88	18.52	42.50	100.00		6.8	261	3.1		
																8.7	277	7.7		
																10.8	311	13.8		
																12.0	----	----		
1606	Bucks	9				0.76	1.70	4.80	8.60	7.50	7.30	37.64	30.54	98.84	656	6.7	234	4.7	7.2	0.32
																8.5	237	5.3	7.7	0.42
																10.4	216	6.3	7.2	0.30
																12.6	----	5.3	----	----

1607	Bucks	0				1.10	2.96	7.40	11.14	8.60	8.84	35.46	24.10	99.60	640	6.4 8.4 10.4 12.1 13.9	206 228 207 ---- ----	4.2 6.7 7.2 7.9 4.4	9.0 7.3 7.0 ---- ----	0.39 0.29 0.32 ---- ----
1608	Bucks	1				3.60	5.40	6.74	10.44	8.40	8.10	31.94	24.84	99.46	648	6.4 7.9 10.4 12.4 14.3	219 221 211 ---- ----	5.3 7.0 8.8 9.4 2.4	9.4 8.2 6.8 ---- ----	0.39 0.45 0.42 ---- ----
1609	Bucks	1 open		Tr.	Tr.	6.70	10.60	14.80	18.80	9.60	6.24	19.80	13.10	99.64	520	4.5 5.7 7.9 10.0 11.2	163 171 160 ---- ----	16.2 21.0 25.8 27.0 19.0	5.8 4.9 4.3 ---- ----	0.23 0.29 0.32 ---- ----
1610	Bucks					1.50	6.10	7.90	10.40	10.76	12.24	32.80	17.46	99.16		5.7 7.9 10.4 11.8 13.1	177 179 183 167 ----	7.7 10.3 11.0 13.3 7.5	5.8 5.2 5.1 4.8 ----	0.16 0.35 0.26 0.42 ----
1611	Bucks	1				3.54	18.50	18.80	11.60	8.28	7.04	20.04	12.42	99.62		4.3 6.2 8.2 9.9	150 160 148 ----	13.0 21.0 28.0 27.0	5.1 5.1 4.2 ----	0.25 0.29 0.16 ---
1612	Bucks	2			Tr.	6.50	20.86	17.24	9.20	6.54	5.34	19.20	14.06	98.94		3.8 6.2 8.4 10.5	158 167 159 ----	8.8 18.4 24.2 16.2	6.6 5.2 4.8 ----	0.23 0.32 0.35 ----
613	Bucks	No. 0		.16	.26	3.26	12.66	6.36	5.46	6.22	12.64	25.48	27.46	99.96	704	6.4 8.5 10.4 12.7	203 209 194 ----	7.9 9.4 12.2 6.7		
614	Bucks	No. 4		.10	.50	5.60	24.54	11.60	7.22	1.84	7.44	17.16	20.14	99.54	376	6.1 8.4 10.4	185 199 162	15.7 22.7 14.9		
1601	Cambria					1.88	12.90	18.00	13.90	8.88	5.76	17.64	20.50	99.46		6.3 8.3 10.1 11.6	190 233 223 ----	14.3 19.0 19.5 17.3	8.1 8.2 7.6 ----	0.42 0.42 0.42 ----

Tests of natural-bonded molding sands.

Lab. No.	County	Grade or use	Screen analysis											Dye Adsorption	Water per cent	Bond strength	Permeability	Compression lbs. per sq. in.	Tensile strength lbs. per sq. in.
			On 6	On 12	On 20	On 40	On 70	On 100	On 140	On 200	On 270	Through 270	Clay	Total						
636	Cameron				Tr.	.20	16.80	19.10	15.14	9.36	10.94	12.34	16.00	99.88	1040	4.0 6.1 8.2 10.1	---- 176 169 ----	12.6 19.5 30.0 27.0		
637	Cameron					Tr.	12.48	18.64	16.34	10.28	11.06	11.90	19.16	99.86	1200	6.2 8.3 10.3 12.0 14.2	---- 190 201 205 180	11.4 14.3 14.7 19.5 10.3		
611	Columbia	Medium		.26	.46	2.00	13.24	6.20	4.94	5.70	16.14	38.82	12.18	99.94	344	3.9 8.1 6.1 10.3 12.4	---- 157 131 157 159	7.7 11.4 12.2 10.7 ----		
612	Columbia	Fine		.38	.84	4.62	4.74	4.66	6.44	8.56	21.54	37.10	10.80	99.68	344	4.2 6.0 8.2 9.7 12.3	155 174 173 ---- ----	6.7 7.7 8.2 9.7 9.4		
1604	Columbia	No. 1				2.24	5.14	4.04	4.48	6.80	10.14	39.26	17.66	99.16	560	4.3 6.0 8.0 8.9	179 211 190 ----	4.9 6.7 8.5 6.5	5.9 6.2 5.9 ----	0.16 0.39 0.35 ----
675	Columbia	Gen'l.				0.32	10.96	18.40	13.24	10.40	12.90	21.90	11.20	99.32		4.0 6.2 8.3 10.0	143 170 149 ----	11.0 15.2 16.7 16.2	4.8 4.8 4.3 ----	.10 .16 .32 ----

635	Columbia	AA.				Tr.	11.34	6.54	6.92	7.28	16.96	40.24	10.44	99.72	840	5.7 7.8 10.0	164 169 155	10.3 11.8 9.0		
649	Crawford					Tr.	.18	2.40	7.30	9.14	21.18	45.30	14.20	99.70	400	3.6 5.7 7.6 9.8	116 149 144 ----	6.7 10.7 14.7 10.7		
640	Elk	Loam					1.14	4.94	8.58	9.50	12.80	22.64	40.20	99.50	10.88	6.6 8.0 10.4 12.4 13.5	245 276 249 ---- ----	1.9 2.9 4.7 5.6 6.3		
643	Elk	No. 1				.54	17.08	20.08	14.70	7.86	9.28	13.14	16.96	99.64	820	6.2 8.2 10.2 11.7	165 207 191 ----	14.7 20.0 25.8 25.8		
638	Elk	No. 4			Tr.	1.24	16.00	17.74	13.94	8.38	10.36	13.76	18.44	99.86	860	6.1 8.9 10.0 11.8	199 207 185 ----	15.2 21.8 29.0 19.0		
644	Erie	No. 1-H.		.36	2.10	5.10	12.70	20.84	17.92	9.08	8.98	12.30	10.12	99.50	544	4.4 6.4 8.6 9.7 11.7	---- 178 171 165 ----	10.7 14.3 17.8 21.0 19.0		
645	Erie	No. 3-E.		.38	3.54	12.48	29.40	8.64	3.24	1.72	3.66	13.10	23.56	99.72	640	7.0 8.3 11.0 11.6 13.1	209 214 213 ---- ----	9.7 17.3 33.0 88.0 24.2		
641	Erie	No. 1-V.			Tr.	.84	.74	.76	6.24	18.40	27.18	23.20	22.30	99.66	840	6.6 8.5 10.8 11.7 14.0	205 210 204 ---- ----	7.5 8.5 10.7 12.6 7.0		
647	Erie	No. 1½ H.		.20	1.96	5.18	16.74	42.00	9.58	3.96	5.04	8.24	6.96	99.86	352	4.5 6.6 8.8 9.2 10.0	---- 163 156 ---- ----	14.7 25.8 30.0 40.0 34.0		

Tests of natural-bonded molding sands.

Lab. No.	County	Grade or use	Screen analysis												Dye Adsorption	Water per cent	Bond strength	Permeability	Compression lbs. per sq. in.	Tensile strength lbs. per sq. in.
			On 6	On 12	On 20	On 40	On 70	On 100	On 140	On 200	On 270	Through 270	Clay	Total						
648	Erie				.28	.84	1.34	2.50	5.90	7.70	17.56	35.94	27.60	99.66	576	5.5	224	3.7		
																8.4	210	7.0		
																10.3	----	5.8		
692	Fayette	Iron pipe		.94	1.60	16.24	34.60	14.74	7.30	3.00	3.10	4.24	14.40	100.16		4.3	200	72	7.5	0.52
																4.8	224	87	10.1	0.52
																6.8	206	122	6.8	0.42
																9.1	147	102	4.9	0.35
694	Fayette	Gray iron	4.00	1.10	0.96	12.74	26.84	14.70	8.20	3.88	4.19	6.84	15.86	99.22		4.6	201	25.8	11.1	0.58
																6.7	219	38.0	9.1	0.48
																8.9	197	58.0	7.0	0.42
																10.3	----	93.0	----	----
																13.5	----	1.1	----	----
695	Fayette				.76	4.44	14.70	16.30	11.60	7.24	7.90	12.24	24.30	99.48		6.2	231	18.4	11.2	0.58
																8.3	268	23.4	10.9	0.65
																10.6	249	36.0	8.3	0.58
																11.7	----	6.7	----	----
696	Fayette	Core	4.76	3.54	6.16	28.44	20.58	5.78	3.44	1.90	2.68	4.80	17.90	99.98		7.1	266	148	11.9	0.97
																8.9	275	178	9.7	0.87
																11.5	250	79	7.3	0.52
699	Fayette			Tr.	Tr.	4.60	20.30	15.70	11.80	7.44	7.48	10.54	21.60	99.46		4.4	205	16.7	9.7	0.48
																6.5	229	58.0	8.0	0.48
																8.7	200	58.0	7.4	0.32
																11.3	----	62.0	----	----
																12.7	----	30.0	----	----
622	Franklin				Tr.	5.34	28.00	17.90	11.20	6.14	6.04	7.60	16.66	98.88		4.4	197	22.7	10.7	0.65
																7.4	243	29.0	10.8	0.68
																9.6	208	58.0	6.9	0.48
																10.7	----	49.0	----	----

671	Lancaster	Gray iron				.70	3.64	3.40	4.14	9.16	19.84	44.30	14.10	99.28		4.2 5.9 8.4 10.8	138 162 148 ----	5.6 7.7 10.7 8.2	4.2 4.1 4.4 ----	0.13 0.10 0.10 ----
672	Lancaster					.40	2.10	2.04	4.90	6.00	18.30	46.60	19.04	99.38		4.1 6.4 8.2 10.4 11.5	117 167 180 179 ----	4.7 5.3 5.8 6.5 6.0	4.3 5.8 5.8 5.4 ----	0.10 0.16 0.13 0.42 ----
607	Lehigh	Cores		7.04	11.10	24.38	20.40	6.60	3.34	1.76	2.48	5.90	17.32	100.32		5.9 8.2 10.1 12.1	160 163 182 150	6.7 17.3 33.0 12.0		
608	Lehigh			.04	.08	.22	2.00	7.40	10.36	9.42	16.92	26.40	27.28	100.12		6.1 8.0 10.2 12.5	---- 165 150 ----	7.2 10.0 12.2 11.4		
606	Lehigh					.04	4.10	14.96	17.10	13.44	17.30	22.74	10.16	99.84		3.9 8.1 5.8 10.3 12.5	---- 133 132 146 143	9.0 17.8 13.8 20.0 21.8		
658	McKean	No. 16			7.30	37.74	23.18	5.38	2.70	1.28	1.68	4.18	16.26	99.70	480	3.6 5.7 7.4 9.0 11.5	144 172 145 ---- ----	29 75 193 235 21		
659	McKean	No. 20			2.28	33.66	31.12	5.98	2.68	1.10	1.40	4.04	17.40	99.66	800	4.5 5.8 7.8	173 183 182	25.8 138.0 115.0		
660	McKean	No. 30			.50	32.50	31.00	6.44	3.14	1.50	1.88	4.54	18.26	99.76	440	3.7 5.8 7.8 9.5 12.3	131 173 168 ---- ----	16.7 58.0 128.0 138.0 1.9		
661	McKean	No. 40			Tr.	29.90	34.94	7.18	3.38	1.54	1.78	4.30	16.60	99.62	460	3.4 5.8 8.0 9.4	149 183 147 ----	16.2 54.0 102.0 99.0		

Tests of natural-bonded molding sands.

Lab. No.	County	Grade or use	Screen analysis												Dye Adsorption	Water per cent	Bond strength	Permeability	Compression lbs. per sq. in.	Tensile strength lbs. per sq. in.
			On 6	On 12	On 20	On 40	On 70	On 100	On 140	On 200	On 270	Through 270	Clay	Total						
662	McKean	No. 50			Tr.	4.74	38.68	12.70	6.68	3.58	3.68	7.44	21.72	99.22	448	3.7 6.0 8.0 9.7	---- 240 205 ----	8.8 24.2 42.0 30.0		
634	Montour	AAA-H					.80	1.74	5.68	9.50	24.86	46.18	11.22	99.98	544	4.2 3.6 5.8 7.8 9.9	149 ---- 150 155 158	9.7 7.9 13.4 11.4 8.2	5.5	0.32
679	Montour	Stove				.44	1.74	2.44	5.30	7.14	21.04	47.10	14.44	99.64		6.4 8.0 10.3 12.2	164 171 176 172	7.7 10.7 7.5 7.5	4.9 4.7 4.8 4.5	0.39 0.35 0.48 0.32
680	Montour				Tr.	36.04	24.20	14.34	2.90	2.40	2.90	5.54	11.46	99.78		4.1 5.8 8.0 9.4	---- 160 139 ----	49.0 96.0 108.0 105.0	---- 5.0 3.5 ----	---- 0.32 0.29 ----
676	Montour	Stove				.30	1.60	6.80	11.04	12.48	23.64	32.40	11.04	99.30		4.2 6.3 8.3 9.1 10.6	149 158 155 ---- ----	9.7 12.2 14.3 18.4 12.6	5.5 4.8 4.3 ---- ----	0.32 0.35 0.39 ---- ----
677	Montour	Gen'l.				.30	6.24	23.10	19.74	15.10	13.90	13.00	8.10	99.48		3.2 4.1 6.1 7.8	---- 161 142 ----	16.2 21.8 29.0 15.2	3.7 3.9 3.5 ----	0.32 0.29 0.32 ----
678	Montour				Tr.	.30	.88	2.24	4.64	6.24	20.20	48.70	15.56	98.76		4.3 6.3 8.3 10.2	177 172 189 177	4.4 5.3 7.0 6.5	6.7 6.9 6.8 5.4	0.42 0.42 0.45 0.45

631	Northumberland	B-G			Tr.	.76	14.54	18.64	12.58	9.10	10.38	13.24	20.36	99.60	760	4.1 6.1 8.1 9.6 12.3	---- 248 236 ---- ----	12.2 21.8 33.0 40.0 13.4		
632	Northumberland	A-D					.90	2.74	5.14	9.10	24.50	44.94	12.46	99.78	480	5.7 7.5 10.1	153 166 152	11.0 13.0 11.8		
633	Northumberland	AAA-G					1.38	6.06	11.48	12.08	21.20	33.50	14.00	99.70	920	5.8 7.7 10.1	158 161 162	13.4 14.7 11.0		
343	Northumberland	No. 6		.12	.02	.12	1.86	6.76	10.50	11.06	22.40	35.04	12.62	100.50	544	4.0 6.0 7.0 8.8 14.7	---- 150 145 ---- ----	9.9 10.1 11.0 17.8 8.8		
666	Northumberland	B-G			Tr.	1.90	12.56	15.44	12.34	8.90	11.44	19.24	17.36	99.18		4.4 6.5 8.3 10.0	203 198 195 ----	7.9 14.7 20.0 14.7	9.7 7.9 6.1 ----	0.45 0.26 0.16 ----
654	Venango	No. 2		Tr.	.44	5.14	8.90	9.88	11.96	10.70	16.90	21.10	14.98	100.00	520	2.5 3.7 5.9 8.5 10.7 12.4	---- 92 129 140 149 156	10.7 72.0 31.0 30.0 18.4 9.7		
655	Venango			Tr.	1.28	8.02	8.74	10.28	10.46	7.54	10.78	17.62	24.50	99.22	600	3.6 5.6 8.0 10.2	94 153 136 ----	16.2 28.0 77.0 42.0		
684	Westmoreland					.96	16.90	18.36	13.04	9.14	8.44	12.80	20.36	100.00		6.7 8.6 10.3 11.8	229 246 231 ----	14.7 21.8 23.4 13.8	9.9 9.2 7.7 ----	0.45 0.52 0.55 ----
685	Westmoreland	Gen'l.		1.70	3.30	14.34	15.40	4.00	2.76	2.14	3.18	10.94	41.10	98.86		6.3 8.2 10.2 12.1 12.6 13.2	256 300 299 ---- ---- ----	7.2 11.4 16.7 25.8 34.0 36.0	14.9 14.2 12.0 ---- ---- wet	0.93 0.93 0.81 ---- ----

Tests of natural-bonded molding sands.

Lab. No.	County	Grade or use	Screen Analysis												Dye Adsorption	Water per cent	Bond strength	Permeability	Compression lbs. per sq. in.	Tensile strength lbs. per sq. in.
			On 6	On 12	On 20	On 40	On 70	On 100	On 140	On 200	On 270	Through 270	Clay	Total						
691	Westmoreland		10.50	7.44	5.10	25.74	10.50	8.40	3.70	2.00	3.44	9.10	14.28	100.20		5.9	156	36.0	6.0	0.35
																8.5	158	79.0	4.9	0.32
																10.3	162	25.8	4.7	0.35
697	Westmoreland		2.90	4.96	4.84	19.60	26.14	8.20	5.60	1.84	2.30	6.30	17.24	99.92		4.9	207	87	9.2	0.42
																6.8	266	93	9.6	0.58
																8.6	218	105	7.9	0.58
																9.9	----	62	----	
698	Westmoreland				Tr.	6.04	34.56	21.04	10.70	5.64	5.40	7.40	8.96	99.74		4.3	124	28	4.6	0.23
																6.0	140	49	4.2	0.23
																8.4	130	58	3.5	0.26
																9.5	----	55	----	----
663	York					4.04	19.84	17.80	10.28	6.66	7.24	12.94	20.40	99.20		5.5	150	10.7	6.7	0.16
																8.5	165	20.0	6.2	0.35
																10.1	134	40.0	4.1	1.00
																10.9	----	25.8	----	----
664	York					1.00	6.00	7.00	8.44	7.70	10.40	22.84	36.34	99.72		3.7	169	2.6	9.5	0.26
																6.7	232	3.5	10.7	0.61
																8.7	205	4.4	10.4	0.65
																10.0	----	5.8	----	----
																12.7	----	6.7	----	----
																13.6	----	7.2	----	----
673	York				Tr.	.74	3.00	2.28	2.54	3.30	12.28	51.56	22.86	98.56		4.2	156	3.1	5.2	0.45
																5.8	177	3.5	5.2	0.45
																8.3	189	3.7	6.6	0.52
																10.5	191	4.4	6.7	0.48
																12.0	188	4.4	5.8	0.45

Lab. No	County	Grade or use	Screen Analysis: On 6	On 12	On 20	On 40	On 70	On 100	On 140	On 200	On 270	Through 270	Clay	Total	Dry Adsorption	Water per cent	Bond strength	Permeability	Compression lbs. per sq. in.	Tensile strength lbs. per sq. in.
680	Allegheny	Cores	2.40	9.54	7.60	47.34	25.50	4.44	1.36	0.54	0.40	0.40	0.70	100.22		Dry		243		
681	Blair	Steel	Tr.	0.90	0.34	7.84	41.08	28.44	6.90	1.80	1.76	2.84	6.86	98.76		2.9	106	87.0		
																3.8	96	102.0		
																5.8	95	112.0		
																7.5	----	79.6		
682	Blair	Core	1.70	1.20	0.50	7.80	29.84	19.64	6.96	2.18	2.28	5.14	22.70	99.94		3.9	----	19.0	6.3	0.45
																6.6	234	67.0	8.1	0.52
																8.4	173	79.0	6.9	0.35
																9.0	----	49.0	----	----
615	Butler	No. 1			2.80	27.45	53.65	8.53	3.37	1.23	.98	1.73	----	99.74	72	0	----	155		
616	Butler	No. 2			.04	9.52	67.49	13.12	9.80	1.49	1.25	1.79	----	104.50	40	0	----	112		
617	Butler	No. 3			.40	3.62	17.05	28.80	22.32	11.96	8.50	7.07	----	99.72	144	0	----	22		
1605	Chester	Steel	5.14	5.84	6.08	25.50	13.84	8.74	7.14	3.94	4.08	11.10	8.30	99.70	112	5.6	112	49.0	4.3	0.29
																7.8	116	67.0	3.5	0.29
																9.5	92	85.0	2.8	0.19
																11.2	----	49.0	----	----
674	Cumberland	Not used	Tr.	5.30	6.00	22.54	13.54	14.04	20.80	7.74	3.10	3.10	2.46	98.62		Dry		38		
667	Cumberland	Not used		2.30	2.10	22.30	34.10	14.40	6.60	2.20	2.08	1.20	9.10	99.38		4.0	86	126	1.4	0.07
																6.0	87	193	1.8	0.13
																7.9	82	167	1.7	0.13
668	Cumberland	Not used		Tr.	0.60	4.36	10.54	20.84	37.18	13.64	5.60	3.54	2.60	98.90		3.9	76	72		
																5.7	85	79		
																8.1	87	75		
																9.7	92	62		
639	Elk	Steel		.94	4.88	23.44	54.18	4.90	2.28	1.00	1.00	2.14	5.28	100.04	240	5.6		610		

Tests of silica sand.

Lab. No.	County	Grade or use	Screen analysis											Dye Adsorption	Water per cent	Bond strength	Permeability	Compression lbs. per sq. in.	Tensile strength lbs. per sq. in.
			On 6	On 12	On 20	On 40	On 70	On 100	On 140	On 200	On 270	Through 270	Clay	Total						
646	Erie	Core No. 6. FV.		9.14	45.00	15.60	1.44	.60	.54	.34	.96	9.44	17.10	100.16	680	5.9 7.8 9.8	164 148 ----	48 610 610		
693	Fayette	Steel		Tr.	1.50	17.00	50.64	19.80	7.30	1.88	0.90	0.44	0.20	99.66			Dry 146			
621	Franklin			2.88	4.00	36.68	27.04	7.50	4.10	1.84	1.74	4.14	8.94	98.86		2.7 4.0 6.1 7.9	---- 73 71 ----	122 219 275 243	---- 1.3 1.6 ----	---- 0.13 0.16
665	Franklin		Tr.	5.64	5.30	39.34	26.14	7.00	3.80	1.30	1.44	2.84	6.84	99.64		4.1 5.7 7.9 9.6	67 71 69 ----	275 300 326 235	---- ---- 1.2 ----	---- ---- 0.13 ----
623	Franklin			0.90	2.98	17.20	22.40	10.44	8.30	5 04	4.86	6.28	20.36	98.76		6.0 7.9 10.0	302 315 237	10.7 31.0 21.0	11.8 11.9 8.7	0.81 0.81 0.74
620	Franklin	Not used		1.86	4.68	28.64	26.94	23.60	6.50	1.94	1.16	1.10	2.84	99.16						
656	Jefferson	Steel		1.78	9.14	29.58	33.36	9.50	3.44	1.28	1.28	2.56	7.96	99.88	480	3.3 5.6 7.5 10.0	78 87 68 ----	138 156 167 167		
657	Jefferson	Not used			7.38	45.24	36.64	5.68	2.00	.54	.36	.50	1.62	99.96	144	Dry	----	287		
669	Lancaster	Steel		15.24	9.96	22.24	8.30	4.20	7.04	7.08	9.80	9.84	5.44	99.24		3.8 5.6 8.0 9.2	121 127 119 ----	17.3 28.0 38.0 38.0	4.2 3.9 3.6 ----	0.23 0.19 0.26

670	Lancaster	Not used		4.34	7.04	22.50	10.10	4.80	7.74	9.10	12.90	12.74	8.04	99.30		3.7 5.6 7.8 9.2 9.5	136 157 136 ---- ----	10.0 14.3 15.7 18.4 15.7	4.5 4.7 4.4 ---- ----	0.16 0.19 0.39 ---- ----
1602	Lebanon	Not used		0.38	7.00	39.86	27.24	11.24	3.96	1.50	1.44	2.90	3.90	99.42	156	3.9 5.8 7.6	69 73 66	275 313 287	1.0 1.2 1.4	0.13 0.13 0.16
1603	Lebanon	Not used	2.24	17.00	12.86	31.54	18.26	7.04	2.54	0.94	0.90	1.98	4.46	99.76	160	3.9 5.8 7.4 9.0	60 71 67 ----	341 376 440 326	0.9 1.3 1.0 ----	0.13 0.10 0.16 ----
602	Lycoming	Cores		.22	.12	1.57	38.34	36.12	10.86	3.41	3.38	5.75		99.77		0	----	118		
650	Mercer			2.94	2.58	14.28	52.84	14.78	5.64	2.08	1.40	1.14	1.86	99.54	120	Dry	----	99		
651	Mercer			1.34	2.28	16.00	47.44	17.04	6.74	2.18	1.68	1.80	3.16	99.66	80	57	78	212		
652	Mercer	Not used			.20	1.84	17.74	20.68	15.00	8.86	10.44	16.06	9.26	100.08	208	5.9 7.7 10.0 12.4	119 122 129 126	24.2 28.0 31.0 28.0		
601	Mifflin	Steel		.11	.31	4.51	64.26	21.33	5.56	1.69	1.15	1.00		99.92		0	----	118		
618	Venango			.05	.70	4.60	57.88	26.46	6.81	1.57	.69	1.11		99.87	72	0	----	100		
619	Venango			.06	1.03	7.17	66.44	19.29	4.34	.80	.49	.29	----	99.91	72	0	----	143		
653	Venango			.58	10.80	78.34	2.58	.52	.50	.26	.38	.66	5.50	100.12	80	3.7 5.6 7.7	83 78 ----	287 440 173		
683	Westmoreland			0.94	4.70	35.34	37.70	12.24	4.90	1.44	0.94	0.90	0.84	99.94		Dry		122		
689	Westmoreland			0.76	4.54	25.70	48.20	9.90	4.44	1.80	1.34	1.24	2.10	100.02		Dry		162		

Classification of Pennsylvania foundry sands by grain size and clay content.

Lab. No.	Grain size	Grain class	Clay class	Lab. No.	Grain size	Grain class	Clay class	Lab. No.	Grain size	Grain class	Clay class	Lab. No.	Grain size	Grain class	Clay class
601	55	5	------	635	203	1	E	662	86	4	G	689	46	6	C
602	81	4	------	636	128	3	F	663	120	3	G	690	28	8	B
603	129	3	G	637	132	3	F	664	183	2	H	691	67	5	E
604	93	4	F	638	131	3	F	665	44	6	D	692	144	2	E
605	173	2	H	639	45	6	D	666	149	2	F	693	51	5	A
606	168	2	E	640	201	1	H	667	61	5	D	694	79	4	F
607	57	5	F	641	203	1	G	668	99	4	C	695	123	3	G
608	196	2	G	643	127	3	F	669	84	4	D	696	54	5	F
611	196	2	E	644	119	3	E	670	107	3	D	697	63	5	F
612	201	1	E	645	96	4	G	671	227	1	E	698	89	4	D
613	174	2	G	646	49	6	F	672	239	1	F	699	114	3	G
614	126	3	G	647	94	4	D	673	250	1	G	1600	92	4	G
615	45	6	------	648	225	1	G	674	70	4	C	1601	138	3	G
616	55	5	------	649	234	1	E	675	155	2	E	1602	47	6	C
617	105	3	------	650	51	5	B	676	202	1	E	1603	34	7	C
618	56	5	------	651	55	5	C	677	138	3	D	1604	228	1	F
619	49	4	------	652	130	3	D	678	243	1	F	1605	78	4	D
620	50	5	C	653	23	8	D	679	236	1	E	1606	221	1	H
621	52	5	D	654	159	2	E	680	63	5	E	1607	204	1	G
622	97	4	F	655	144	2	G	681	65	5	D	1608	190	2	G
623	82	4	G	656	46	6	D	682	74	4	G	1609	139	3	E
624	67	5	G	657	34	7	B	683	43	6	B	1610	195	2	F
631	132	3	G	658	60	5	F	684	127	3	G	1611	135	3	E
632	234	1	E	659	52	5	F	685	99	4	H	1612	225	1	E
633	205	1	E	660	57	5	F	687	108	3	E				
634	235	1	E	661	51	5	F	688	241	1	1				

TESTS OF SAND FROM OTHER STATES

Following is a list of a few sands from New Jersey, New York, and Ohio whose tests are similar to those of some Pennsylvania sands.

NEW JERSEY

No. 506. Dorchester, Cumberland County. Chas. E. Pettinos, operator.
No. 518 Blenheim, Camden County. Cummins Bros., operator.
No. 520. Lumberton, Burlington County. Brennan Sand Co., operator.
No. 524. Masonville, Burlington County. J. W. Paxson Co., operator.
No. 525. Bridgeboro, Burlington County. Hainesport Mining and Transportation Co., producer.
No. 532. South Amboy, Middlesex County. Whitehead Bros., operators.
No. 536. Phillipsburg, Warren County. Steckel Sand Co., operator.

NEW YORK

These samples are from different pits located between Mechanicsville and Poughkeepsie. The grade numbers are those of the producer.

OHIO

Two sands from Zanesville were collected at a Chicago foundry and the tests published in Illinois Geological Survey report on molding sand.[1]

[1]Littlefield, M. S., Natural-bonded molding sand resources of Illinois: Illinois Geol. Survey Bull. 50, p. 172, 1925.

Tests of molding sands from other States.

Lab. No.	Locality	Grade or use	Screen analysis											Dye Adsorption	Water per cent	Bond strength	Permeability	Compression lbs. per sq. in.	Tensile strength lbs. per sq. in.
			On 6	On 12	On 20	On 40	On 70	On 100	On 140	On 200	On 270	Through 270	Clay	Total						
506	Dorchester N. J.	Molding sand		.08	.58	2.16	29.18	33.54	14.62	3.26	2.40	2.42	11.52	99.76	944	2.8 3.9 6.0	160 182 132	72 93 80		
518	Blenheim N. J.	Fine molding sand		.16	.10	.02	.72	.68	2.62	13.92	33.46	28.76	19.42	99.86	1336	3.7 6.0 8.2 10.3	---- 158 164 166	9.7 12.2 11.4 11.4		
520	Lumberton N. J.	Lumberton loam		.50	1.72	.10	19.76	14.86	12.50	10.34	11.42	9.76	18.96	99.92		5.0 7.0 8.0	208 225 223	23 28 25		
524	Masonville, N. J.	Lumberton loam		.08	1.08	.28	45.14	25.66	12.00	3.82	1.52	.34	9.84	99.76		3.0 5.0 8.0	(1) 278 175	97.7 107.0 69.5		
525	Bridgeboro, N. J.		.60	1.70	3.46	1.22	49.70	18.48	10.10	4.24	2.16	1.04	7.22	99.92	576	3.4 4.3 6.1 8.4	178 163 119 110	93 105 80 72		
532	South Amboy N. J.	Molding loam		.44	.88	4.04	8.94	4.84	3.00	2.54	5.02	25.00	45.20	99.96	972	6.8 8.6 10.9 14.1 16.0	137 183 222 247 (2)	3.1 4.0 6.3 8.8 (2)		
536	Phillipsburg N. J.	Molding loam				.44	35.30	21.28	11.62	6.18	6.92	9.52	8.46	99.72	240	4.2 6.0 7.8 9.8	118 117 115 ----	55 58 62 55		
686	West Albany N. Y.	No. 1½				.28	8.60	18.14	15.20	10.84	13.28	26.30	7.20	99.84		4.0 5.5 7.9 9.3	151 169 166 ----	10.7 14.3 15.7 14.7	4.3 4.4 4.3 ----	0.13 0.26 0.13 ----

209	Albany district, N. Y.	00 strong		.14	.06	.26	1.16	1.28	2.26	4.94	21.84	47.68	21.12	100.74	336	4.0 6.0 8.0 9.6 11.5	182 203 200 ---- ----	3.15 5.43 5.8 10.7 7.5		
249	Albany district, N. Y.	00 open			.06	.02	1.92	3.46	12.36	16.48	19.34	26.54	19.52	99.70	276	4.0 6.0 8.0 12.0	(1) 172 172 169	6.7 8.2 9.4 8.8		
254	Albany district, N. Y.	00		.26	.12	.32	.86	2.44	5.88	12.68	31.52	33.00	13.08	100.16	272	4.0 6.0 8.0 9.7 11.7 13.6	171 186 181 ---- ---- ----	3.5 6.5 8.8 10.0 13.0 8.2		
361	Albany district, N. Y.	00-P		.16	.22	.40	2.32	1.36	2.68	5.56	23.04	46.76	17.00	99.62	304	6.2 7.8 10.5 13.2	159 171 179 176	7.7 8.2 9.0 7.2		
207	Albany district, N. Y	0	.30	.38	.18	.30	2.12	4.92	8.50	12.42	23.64	34.08	12.76	99.60	276	3.9 6.1 8.6 9.6	142 181 172 ----	7.5 10.1 11.7 10.7		
251	Albany district, N. Y.	0 strong		.04	.06	.04	.54	1.60	6.34	8.48	19.58	39.62	21.08	100.38	276	4.0 6.0 7.5 9.5 11.8	(1) 174 188 187 ----	4.0 5.3 6.3 7.2 6.5		
206	Albany district, N. Y.	Albany No. 1.		.04	.10	.42	3.50	3.04	3.54	4.38	16.08	44.72	18.92	99.74	608	3.7 6.2 8.3 9.7 11.3 13.8 14.8	185 199 199 ---- ---- ---- ----	3.7 6.4 7.1 8.5 9.9 9.7 6.5		
240	Albany district, N. Y.	Albany No. 1. open medium			.10	.34	1.02	4.48	11.70	15.82	27.68	26.64	12.26	100.04	244	3.8 5.8 8.0 9.7 11.9	---- 151 153 145 ----	12.2 17.3 15.7 11.4 11.4		

(1) Too dry. (2) Too wet.

Tests of molding sands from other States.

Lab. No.	County	Grade or use	Screen analysis											Dye Adsorption	Water per cent	Bond strength	Permeability	Compression lbs. per sq. in.	Tensile strength lbs. per sq. in.
			On 6	On 12	On 20	On 40	On 70	On 100	On 140	On 200	On 270	Through 270	Clay	Total						
250	Albany district, N. Y.	Albany No. 1.		.16	.16	.50	4.76	8.08	11.12	10.98	17.10	23.98	24.00	100.64	404	4.4	(1)	4.0		
																6.6	141	5.3		
																8.5	176	5.8		
																10.0	182	7.2		
																11.6	186	7.0		
																13.1	202	10.0		
																15.4	190	7.5		
213	Do	Albany No. 1½		.46	.64	2.18	11.10	14.96	15.78	13.50	14.84	13.88	12.30	99.64	272	3.8	161	2.2		
																5.6	159	18.4		
																8.0	149	21.2		
																9.6	----	25.8		
																11.7	----	12.2		
371	Do	Albany No. 3-N. R.			.02	.72	19.68	20.18	14.50	8.26	9.46	11.40	16.70	100.92		4.1	197	----		
																6.0	247	24.2		
																8.3	188	44.0		
																10.2	----	34.0		
32	Zanesville, Ohio			.7	.6	1.9	18.4	10.7	6.7	5.7	2.7	35.6	16.1	99.1	920	4	145	20.4		
																6	167	15.9		
																8	202	11.1		
																10	220	9.7		
29	Zanesville, Ohio			.6	1.9	9.8	49.8	8.6	3.0	1.1	2.4	11.4	11.2	99.8	880	4	231	77.5		
																6	197	63.2		
																8	136	35.1		

Classification by grain size and clay content.

Lab. No.	Grain size	Grain class	Clay class	Lab. No.	Grain size	Grain class	Clay class	Lab. No.	Grain size	Grain class	Clay class
New Jersey				New York				Ohio			
506	76	4	E	206	209	1	F	29	81	4	F
518	219	1	F	207	207	1	E	32	171	2	E
520	121	3	F	209	248	1	G				
524	64	5	D	213	139	3	E				
525	61	5	D	240	197	2	E				
532	182	2	I	249	197	2	F				
536	101	3	D	250	183	2	G				
				251	233	1	G				
				254	215	1	E				
				361	241	1	F				
				371	120	3	F				
				686	164	2	D				

CONCLUSION

The data now available in the Transactions of the American Foundrymen's Association and in this and similar reports containing standard tests of molding sand make it possible to compare molding sands without handling or using them.

The following table compares the standard tests of certain sands from other States with similar sands produced in Pennsylvania.

Comparison of standard tests of sands from four States.

Locality	Lab. No.	Grain class	Clay class	Bond strength	Permeability	Dye adsorption
Albany, N. Y.	371	3	F	247	24.2	
Ridgway, Pa.	643	3	F	207	29	820
Albany, N. Y.	250	2	G	202	10	404
Tullytown, Pa.	1608	2	G	221	9.4	648
Albany, N. Y.	207	1	E	181	11.7	276
Danville, Pa.	679	1	E	176	10.7	
Albany, N. Y.	254	1	E	186	13	272
Riverside, Pa.	632	1	E	166	13	480
Marietta, Pa.	671	1	E	162	10.7	
Albany, N. Y.	209	1	G	203	10.7	336
North Springfield, Pa.	641	1	G	210	12.6	840
Phillipsburg, N. J.	536	3	D	118	62	240
Walts Mill, Pa.	698	4	D	140	58	
South Amboy, N. J.	532	2	I	247	8.8	972
Ridgway, Pa.	640	1	H	276	6.3	1088
Tullytown, Pa.	1606	1	H	237	6.3	
Zanesville, Ohio.	29	4	F	231	77	
Connellsville, Pa.	694	4	F	219	93	

Such slight differences as are shown by some of these tests may be immaterial in actual foundry practice. If this is so and the evidence is accepted that Pennsylvania can duplicate molding sands produced in other States, then the foundrymen in Pennsylvania and the producers of molding sand should find much profit in the data contained in this report.